December 2013

Temporal Variability and Public Perception: A Noise Pollution and Urban Soundscape Study of San Juan

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Date: Wednesday, December 18, 2013

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An Interactive Qualifying Project submitted to the faculty of

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

DEGREE OF BACHELOR OF SCIENCE

Sponsoring Agency: Junta de Calidad Ambiental

Submission Date:

Wednesday, December 18, 2013

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Abstract

Noise pollution is a rising issue in urban soundscapes worldwide. Our project aided the Junta de Calidad Ambiental (JCA) in advancing the completion of a noise action plan to reduce noise pollution in San Juan. To accomplish this, we studied the urban soundscape through sound level analysis to investigate temporal variability. We also surveyed residents to comprehend the public perceptions of sound. Additionally, we examined noise regulations to determine the degree of their alignment with public perceptions. Ultimately, we developed a basis of research from which future projects in urban soundscape and noise pollution can sample.

Executive Summary

A soundscape is a compilation of all the sounds in an area and how the public perceives them. Noise is the unwanted or negative sound in an area. The human response to noise, which is subjective, may vary depending on source, exposure time, frequency, decibel (dB) reading, and/or ambient noise level. Exposure to noise can negatively impact people's health, causing hearing loss, cardiovascular problems, psychological issues, and sleep disturbances. When noise affects people's health negatively, it becomes noise pollution. In San Juan, the only remaining state-level agency that works to regulate and enforce noise pollution is the Junta de Calidad Ambiental (JCA). The major sources of noise in the San Juan area are traffic, electric generators, air conditioners, speakers/amplifiers, and airplanes. However, there are subjective positive sources of sound, such as coquís, a species of tree frog, and wind rustling leaves on trees.

Previous WPI researchers have only analyzed sound over 24-hour periods at certain sites in San Juan. No study prior to ours analyzed day-to-day variations of noise or the urban soundscape of the city.

The Environmental Protection Agency (EPA) began to create national noise regulations in the 1970s. In 1981, however, funding for the program was cut, and the JCA assumed regulatory powers at the state level in Puerto Rico. There are few effective noise regulations in Puerto Rico, and they are not consistently enforced.

In 2003, nine agencies, including the JCA, formed the Comité Interagencial y Ciudadano ante el Ruido (CICAR) [Translated, the Citizen's Interagency Committee on Noise]. CICAR has been developing an *Action Plan Against Noise in Puerto Rico*, which is designed to reduce and further control noise pollution in San Juan.

Methodology

The purpose of this project was to aid the JCA in furthering the completion of this action plan. We divided this purpose into two goals: to assist the JCA in further understanding the urban soundscape of San Juan, and to explore the perception of noise and analyze how those perceptions are aligned with the current noise regulations. To achieve these goals, we collected and analyzed sound data from eight sites in San Juan, surveyed people near each site to determine the public perceptions, and studied the current regulations to determine if they addressed the public's opinions on noise.

At the eight sites, we collected dB level data continuously for seven days using sound level meters. We performed statistical analysis to quantify the sound level variance from hour to hour and day to day. Additionally, we visited each site and measured the ambient sound level while identifying the prominent sources of sound. To obtain the public's opinion of the sounds around them, we conducted surveys at each site. Then, we correlated the responses and the logged dB levels.

We interviewed local legal experts to determine the effectiveness of noise regulations in reducing noise, as our data indicated that San Juan is very noisy. From the surveys, we investigated how well the current noise regulations addressed the public's opinions on noise. The team asked respondents which sounds bother them, and the survey results were compared to the regulations to determine how closely they correlated.

Results

The data collected show a great deal of temporal variability of noise. From our fieldwork, we were able to attribute some of the noise spikes to traffic. We also found that many sites share several common sources of sound, even though each site ultimately has its own unique sound profile. At sites with more noise, the sounds were more constant; at sites with less noise, the sounds occurred less often. Analysis of survey results revealed that 32% of people felt the sound around them was negative, and 44% felt the sound around them was positive. We found that the government's current noise regulations are not aligned with the public's opinions on noise and are not enforced in a way that effectively changes the public's behaviors relating to noise.

Conclusion

By looking at the temporal variability of our sites, we concluded that sites with more traffic experienced more day-to-day variation over an average week. Based on our survey responses and interviews with local experts, we concluded that there was a disconnect between the public's perception of noise and the regulations and enforcement of noise. This disconnect has numerous consequences – current regulations do not represent the public's opinions on noise sources, and current noise enforcement is ineffective and does not deter future violations of noise regulation.

More work should be done in understanding the urban soundscape of San Juan. We expect that this project will serve as a solid foundation for future research in both noise pollution and soundscape studies.

Recommendations

We propose several recommendations to aid future sound researchers, and to further reduce high noise levels within San Juan.

- **Improved Local Noise Enforcement:** We recommend allowing local police departments to issue fines on noise violations, as well as requiring all officers to carry sound level meters to quantify those violations.

- **Complete Statistical Representation of San Juan:** We recommend that the JCA continue seven-day monitoring at other sites to understand better the temporal variability of sound within San Juan.
- **Further Soundscape Study:** We suggest a cooperative study with local experts at the University of Puerto Rico. Their methods for monitoring biodiversity could be adapted towards an urban soundscape study, incorporating the examination of sources of noise and positive sounds in the environment.
- **Paradigm Shift:** We recommend shifting the focus of future projects on noise pollution from site-specific research to noise source-specific research.
- **Sound Perception Survey:** We recommend that a statistically significant survey be conducted to accurately capture the public's views regarding noise. This survey should be a more in-depth study that will result in suggestions of new regulations, based on more accurate public opinion data.
- **Characterization Protocols:** We propose that the JCA use their sound level meters to record audio of dB spikes to characterize the site during the initial data-gathering period. Additionally, to move towards an urban soundscape study, we recommend an automated system of sound recording and analysis.
- **Construction of Noise Barriers:** We propose that concrete walls, similar to those along highways in the mainland, should be constructed along the train tracks to mitigate the noise from the train near areas where it affects residents.
- **Culture Study:** We recommend an in-depth culture study to help explain why Puerto Rico tends to be very loud, which may help to improve regulations and their enforcement.

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List of Acronyms and Abbreviations

ACR - Área de Control de Ruidos [Translated: Noise Control Area]

BME – Biomedical Engineering

CICAR – Comité Interagencial y Ciudadano ante el Ruido [Translated: Citizen's Interagency Committee on Noise]

CV – Coefficient of Variation

dB – Decibel

EPA – Environmental Protection Agency (USA)

ISO – International Organization for Standardization

IQP – Interactive Qualifying Project

JCA – Junta de Calidad Ambiental [Translated: Environmental Quality Board]

ME – Mechanical Engineering

ONAC – Office of Noise Abatement and Control (USA)

RBE – Robotics Engineering

UPR – University of Puerto Rico

Introduction

Audible sound is fluctuations in atmospheric pressure with frequencies within 20 Hz-20,000 Hz, the range of human hearing ("Sound", n.d.). According to Hansen (1994), these vibrations, when transmitted through a medium, are interpreted as sound by the human ear.

Understanding the soundscape is important in determining the quality of life in an urban setting, according to Pereira (2003). The Canadian musician and composer, Murray Schafer, introduced the concept of a soundscape in the late 1960s and 1970s. He defined a soundscape as a compilation of all types of sounds in a given area or region. A soundscape, therefore, does not only include the unpleasant sounds; it incorporates the pleasant sounds also. He expanded the concept by classifying soundscape evaluation as a field of study. In recent years, more research has been completed in the field of soundscape evaluation, covering topics from measurements to public opinion (Szeremeta and Zannin, 2009).

Szeremeta and Zannin (2009) expanded upon the idea of gaining an understanding of the public's perceptions of their acoustical environment. They compared quantitative data acquired from measuring the levels of sound in an area to the results obtained from administering surveys of the general public in that area. These perceptions, when combined with the quantitative data, help to understand the soundscape.

Hansen (1994) said that at times, sounds can become too stimulating for the brain, and these over-stimulating sounds are classified as noise. Furthermore, Hansen (1994) defined "noise" as any unwanted or undesired sound. Common sense confirms what Kerwin (2012) has said; that is, that sounds become undesired when they interfere with everyday activities such as sleeping, working, or having a conversation.

Kerwin (2012) also notes that some of these unwanted sounds can be observed through the reaction to the noise, as well as the associated annoyance levels. She observed that the reaction to and annoyance factor of each sound depended more on the quality of the sound than the intensity or volume (“Sound”, n.d.).

Coensel et al. (2009) elaborated on Kerwin’s findings, stating that railway noise is less annoying than road traffic noise at the same average sound intensity level. This observation suggests several causes for the difference between the railway and road noise annoyance levels. One cause is the temporal structure of the exposure; that is, the duration of exposure for each noise source based upon the design and use of the source. Another cause is the habituation processes of the sampled individuals. Respondents’ habits and behavioral patterns, including how often they are subjected to the sources of noise in question, can affect their survey responses. Commuters exposed to road traffic noise more often than they are exposed to railway noise may consider railway noise more annoying, even though road traffic noise is more continuous than the periodic railway noise (Coensel et al., 2009).

The human response to noise may vary depending on the exposure time, the frequency, the decibel (dB) reading, the repetition of the noise, and/or the ambient noise level. Stansfeld and Matheson (2003) and Daniel (2007) stated that there can be both auditory and non-auditory effects due to noise. Auditory effects include hearing loss, while non-auditory effects include sleep disturbance, cardiovascular impacts, and psychological impacts.

Noise pollution is defined as any noise which endangers the health and safety of humans (“Regulation for the Control of Noise Pollution”, 2011). It is considered by many policy makers as the “forgotten pollution”, according to Stewart, McManus, and Bronzaft (2011).

Noise pollution regulations nationwide date back to when the US Department of Labor (Standards, 1971) implemented the Occupational Standards and Hazard Act. The Environmental Protection Agency (EPA) was originally charged with regulation of noise pollution at a national level. However, the noise program was defunded at the federal level in 1981, and responsibility was transferred to the states on the grounds that the nature and benefits of such regulations are highly localized (Schapiro, 1993; "Noise Pollution", 2012).

According to Alicea-Pou (2013), the only remaining state-level regulations and enforcement commission in the United States is the Junta de Calidad Ambiental (JCA) in Puerto Rico. This organization regulates all types of environmental issues, from light and noise pollution to water and air pollution. The Área de Control de Ruidos (ACR), a division of the JCA that focuses on noise control, previously had some data on noise pollution and has defined noise pollution for regulatory purposes, as stated above. The ACR faces a lack of recent data on the current noise levels, as well as information on how the noise levels vary from day-to-day.

Representatives from the JCA, along with representatives from the Police of Puerto Rico, the Departments of Health and Education, the Planning Board, the University of Puerto Rico (UPR), and several other organizations, have formed the Comité Interagencial y Ciudadano ante el Ruido (CICAR), or the Citizen's Interagency Committee on Noise (Ambiental, 2009). CICAR is in the process of designing an *Action Plan against Noise for Puerto Rico*. This plan, when finished, will detail how the various departments and organizations can work together to more effectively reduce high levels of noise in San Juan through better regulation, better noise management, and stricter enforcement (Ambiental, 2005, 2010).

The San Juan area has many noise issues. While some are specific to Puerto Rico, other issues are local instances of a more global noise problem. Alicea-Pou (2013) notes that a prominent source of noise pollution is traffic. Areas around the airport are subjected to noise from jet engines. The warm climate also causes many people to run air-conditioning units, adding to the noise. Since San Juan’s electrical grid is inadequate, some residential and business areas have back-up generators, which create substantial background noise (Alicea-Pou, 2013). Other contributors to noise in the urban area are speakers broadcasting music or advertisements. Construction and maintenance in the city also adds to the urban soundscape of San Juan. The coquí (a native species of tree frog), while not considered a source of noise pollution, still contributes to the soundscape of the region through its distinctive cry.

The fundamental purpose of this project was to help the ACR in furthering the completion of the noise action plan. This was divided into two goals. The first goal of this project was to aid the ACR in developing a clearer understanding of the urban soundscape of San Juan. To achieve this goal, our team collected and analyzed noise data from different sites in and around San Juan in order to see if there was a difference in the noise level from day to day.

The second goal of this project was to explore the perceptions of noise in San Juan and how the perceptions are aligned with the current noise regulations. To accomplish this goal, our team investigated the human reaction to and perception of noise at each site. We surveyed the people of the city (that is, residents and tourists) near each site to determine the public perspectives on noise pollution in the city. Lastly, we analyzed current noise regulations to determine if they addressed the public’s opinions on noise. In summary, we analyzed noise pollution’s role in San Juan’s urban soundscape, and set up the foundation for future projects to build upon our work.

Background

The soundscape of an area is dependent on the positive and negative sounds in an area. Noise is defined as the negative sounds, as they are unwanted and harmful. Noise pollution detracts from the quality of the soundscape. Therefore, our project focused on analyzing the soundscape and making recommendations for reducing noise pollution. In this chapter we will discuss what constitutes a soundscape, the technical aspects of noise, major sources of positive sound, major sources of noise, health effects of noise, noise regulations, and noise measurement.

Soundscape

Raimbault and Dubois (2005) stated that the quality of a sound can't be measured simply by its decibel level; rather, this analysis must include a study of the human perception. Murray Schafer started a new approach in the late 1960s and early 1970s wherein the negative effects were not prioritized and the soundscape was analyzed as a whole. Raimbault and Dubois (2005) also said that soundscape analysis depends on the type of sound, the exposed population, and the reasons for exposure. In order to analyze the soundscape, the music and the natural environment were viewed as possible positive sources of sound rather than assuming all the sounds are negative. For example, leaves rustling from the trees and water fountains could be perceived as positive sources of sound. Raimbault and Dubois (2005) also reported that soundscape changes depending on the area or the time of day.

Sound is one of the most prominent ways to interact with the world. The evaluation of the soundscape involves understanding sensory perceptions of sound that are concerned with whether these sounds are enjoyed or disliked, according to Yang and Kang (2007). Zannin et al. (2003) also said that it is important to associate and correlate acoustical measurements with other parameters of evaluation; for example, interviews conducted with the population.

According to Raimbault and Dubois (2005), in order to understand a soundscape, the sources of the sound have to be identified first. The interactions of the people and the noise must be distinguished as well. Next, the temporal variations need to be addressed, because the soundscape can change depending on the time of day, or between days. In order to improve the soundscape, the times of concern would need to be determined.

Technical Aspects of Sound

Audible sound is a wave with a frequency within 20Hz-20,000Hz through a medium ("Sound", n.d.). More specifically, sound waves in air are longitudinal waves, wherein the displacement of the medium is parallel to the direction of travel of the wave (Nave, 1999). A common example used is a wave formed in a spring or "slinky".

Sound waves can be combined. When this is done, the waveforms add together, as seen in Figure 1 (Russell, 1997). This principle, when applied with every individual sound, can create complex wave patterns with beats (Walker, Resnick, & Halliday, 2008).

A sound wave is actually a pressure wave – the movement of air molecules against each other as they are displaced by the energy of the wave creates pressure, which can be used to measure the sound wave ("Background Information for Sound", 2013). This energy can be measured through the displacement of the air molecules. The sound intensity is a measure of the average energy flow through a given area of the medium per unit time ("Sound", n.d.). Sound intensity, while measured in phon, is not the common means of reporting sound levels. More commonly, decibel (dB) level is reported; this is the ratio of the intensity of a sound at a specific frequency to the intensity of a reference sound (the faintest sound that can be heard) at the same frequency ("Sound Intensity (Physics)", n.d.). Sound intensity being objective and independent of observation, decibel is a similarly objective unit for a logarithmic scale for sound reference.

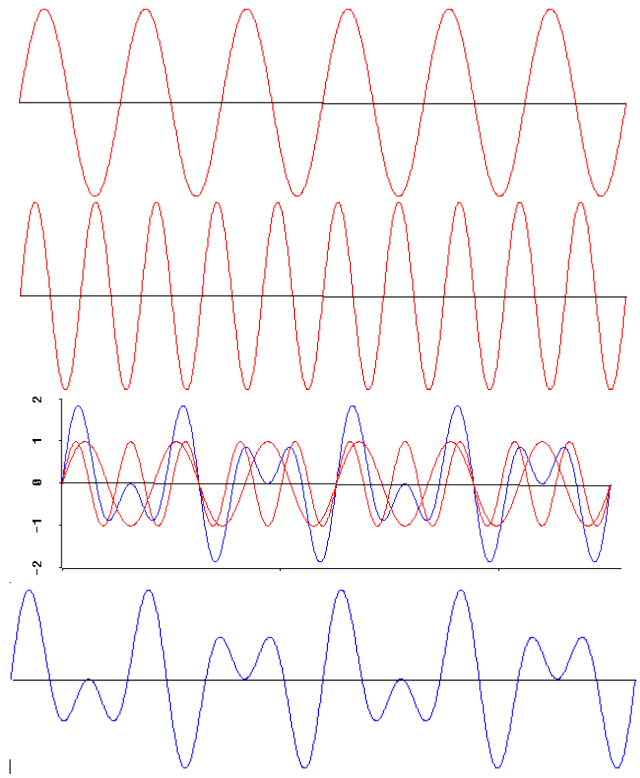


Figure 1: Wave Addition of Different Wave Frequencies Creating Complex Waveforms

Lower frequency noises (or lower pitched noises) remain at the same intensity/loudness for longer times (Earthworks). That is, with a longer wavelength, the lower frequency noise can be heard for a greater distance. Thus, lower frequency noises, while not necessarily as annoying as higher frequency noises, can still raise the ambient intensity and loudness of an area by having a greater area of impact from the source point.

The annoyance factor of the noise does not rely solely on its decibel level. Additional aspects to noise that contribute to the annoyance factor include introducing a new noise to the environment, tonal noise, frequency, periodic sounds, and impulsive sounds (Earthworks).

According to Earthworks, introduction of a new noise source to the prior acoustical background can be distracting and annoying to people in the area. This new noise is more noticeable to those in the area, as they have become accustomed to the ambient sound level.

Møller et al. (2012) note that tonal noise is a major contribution to the annoyance factor of noise. Tonal noise is very noticeable noise, with the energy of the wave concentrated in a single frequency or very narrow frequency band (“A Brief Guide to Noise Control Terms”, 2013). Alternatively, tonal noise is repetitive sound generated by rotating equipment, such as an engine or a fan (Møller et al., 2012). This is a prominent component of the noise pollution issue of Puerto Rico, as many of the major sources of noise such as generators, car engines, and air conditioners can be classified as tonal noise. Similarly, frequency of the noise source can affect how annoying the sound is perceived to be. Higher frequency noises, such as nails on a chalkboard, are more jarring than low- or middle- level frequency noises. Møller et al. (2012) state that at low frequencies, loudness increases more rapidly above the hearing threshold than at higher frequencies. In other words, a noise at a lower pitch can be raised to a higher volume than a high-pitched noise before the noises reach the same hearing threshold.

Periodic, or repetitive, sounds are another aspect of noise contributing to the annoyance factor and therefore becoming a part of the soundscape. The annoyance level dramatically increases when periodic sounds with different decibel and frequency levels are combined (Møller et al., 2012).

Impulsive sounds are sudden spikes of sound, such as a car horn. Experiencing an impulsive sound can be instantaneously distracting and startling, which can be significantly annoying.

Measuring Sound

Sound is measured in decibels, which are units on a logarithmic scale of sound intensity based on human hearing. Audiologists use a number of different factors and parameters to provide further information for a statistical analysis of sound and its environmental impacts. The different parameters take into account the difference between sound intensity and duration. Another important factor in analysis of sound is frequency of the sound, as well as frequency of emission.

Previous sound measurements of San Juan, Puerto Rico, have studied noise pollution in open areas and parks, as well as sound monitoring in the city over 24-hour periods ("Human Perception of Noise in Open Areas in San Juan, PR", 2007). So far, there has not been an extensive noise analysis over week-long intervals in Puerto Rico. This was not due to any limitations of the recording equipment; rather, the variability from one day in a sample week to another day was not considered for previous investigations. In past projects, noise analysis was done by averaging sound measurements collected over 30-minute periods (the recording equipment measured time in this interval). The problem with this procedure of data collection is that it does not account for sudden changes in noise levels, because the information from a burst of loud noise would be lost when averaged out over a half hour. Additionally, past data recorded were only decibel levels and did not include frequency analysis, as this was not the focus of the prior studies.

Positive Sources of Sound

Positive sources of sound are those that are aesthetically pleasing and harmonious. The classification of these sounds as positive is done by subjective analysis rather than objective analysis. Furthermore, determining these sources of sound as positive is based on human perceptions rather than by collection of sound level data.

They are often naturally occurring in the soundscape and can have a beneficial contribution to the environment. Some examples of these sounds can be wind rustling in trees, babbling brooks, and birds singing. Though Puerto Rico is known to be a loud area (Alicea-Pou, 2013), it also has positive sources of sound. In addition to the examples listed above, Puerto Rico also has specific positive sounds, such as coquí frogs and the waves from the ocean.

Sources of Noise

There are many factors that contribute to environmental noise. Muzet (2007) stated that transportation noise is a major contributor, affecting people in cities. He notes that most of the transportation noise is due to the sound of the engines and the sound created by tires as they move over the road surface. At low speeds, engine noise dominates; however, at higher speeds, tire noise begins to exceed engine noise.

Herrera-Montes and Aide (2011) made a similar statement, saying that the level of noise in the metropolitan area of Puerto Rico has risen dramatically. They attribute this to a significant increase in the number of vehicles using Puerto Rican roads. They also stated that the number of cars in the Commonwealth rose from 1 million in 1980 to 2.8 million in 2005.

Industrial activities, such as building construction, are another source of environmental noise. According to Muzet (2007), industrial activities generate high levels of continuous noise that can be heard across long distances. He said that noise caused by industrial activities is complex in nature, because it is caused by various sources with varying intensities.

Chen, Li, and Wong (2000) studied noise from industrial sources in China, and proposed that construction projects should be limited to strategic times of the day. While this would not necessarily reduce noise, it would reduce the annoyance factor of noise. They suggest that noise could also be reduced with advances in technology. According to the authors, noise could be reduced by static crushing, or by using chemicals to break down construction materials instead of using explosives to break apart materials. However, these chemicals could have detrimental effects on the local environment. Chen, Li, and Wong (2000) urged contractors to use quieter, electrically-powered equipment instead of the standard fuel-powered equipment to further reduce noise. They recommended that factories make prefabricated components to keep noise levels low, as these components use laser-cutting technologies in soundproof rooms and can be assembled on site.

The US Department of Transportation has encouraged local governments nationwide to regulate land developments by limiting excessive noise-producing activities to areas of high ambient noise levels near highways (2006).

Muzet (2007) stated that noise levels due to recreational activities are increasing with more frequent use of powered machinery and devices such as boats, off-road vehicles, speakers, and leaf blowers. He stated that these sources of noise are usually limited to specific areas, but in cities they are more common. Every city, due to its unique environment and population, has its own particular soundscape. This is not intended to disregard more rural areas, which can also be characterized by their sound profiles; however, more research has gone into urban sound profiles.

Sources of Noise in San Juan

Noise pollution in San Juan can come from various sources, as stated by Alicea-Pou (2013). He enumerated some of the major sources of noise pollution as traffic (see Figure 2), power generators, sound amplification, and religious ceremonies. Continuing his description, he defined traffic as perhaps the most critical source, due to San Juan’s public transportation vehicles (predominantly taxis, trains, and buses). Herrera-Montes and Aide (2011) further support the claim of traffic as an important source, noting that the increase in the number of cars on the road has been a contributor to the increase of noise pollution levels in Puerto Rico.

Figure 2: Barbosa, Traffic

Alicea-Pou (2013) also cited electrical generators as a major source of noise pollution, due to San Juan's inadequate electrical grid. This inadequacy has led many people to use their own personal power generator to supply electricity. He noted that the widespread usage of generators could significantly increase the noise level in San Juan.

Sound amplification was also detailed as a source of noise pollution. Many of the issues regarding sound amplification are due to music playing from speakers on the street, bars and clubs, music festivals, and concerts.

Finally, he mentioned religious ceremonies as a source of noise pollution as well; however, this can also be classified as an example of sound amplification. Some local churches are known to preach or hold religious services outdoors using electronic sound amplifiers.

Effects of Noise on Health and Sleep

Noise pollution should be reduced, not only because it is disturbing to residents, but because it is damaging to their health. According to Daniel (2007), of all the people in the United States that have hearing impairments, approximately half can be partly attributed to exposure to high-intensity sound. The National Institute of Occupational Safety and Health stated that approximately 30 million people in the US are exposed to levels of noise on a daily basis that could likely cause hearing loss (Daniel, 2007). The rates of children and young adults who develop hearing loss have increased in the past 15 years, according to Serra et al. (2005). According to Daniel (2007), exposure to dangerous levels of noise is likely to be the cause of this hearing loss. Hearing loss, Daniel asserts, is one of the more obvious effects from noise pollution. However, there are additional, often-overlooked effects that will be discussed further.

Noise can affect the endocrine system. In 2003, Stansfeld and Matheson pointed out that a person working in manufacturing has increased levels of adrenaline and noradrenaline, which are secreted when the worker has a high exposure to intense noise. This was based on an earlier study from Cavatorta et al., which studied groups of workers in a glass factory (1987).

Noise effects on the cardiovascular system are still being determined. Stansfeld and Matheson (2003) and Daniel (2007) stated that exposure to noise can increase the heart rate and blood pressure, whether or not noise exposure occurs during sleep. It is difficult to isolate the effect that noise has on the system, as there could be other factors causing the impact. However, Fyhri and Aasvang (2010) suggest that long-term exposure to high levels of noise, such as air and road traffic, could result in high blood pressure or heart attack. Jarup et al. (2008) did a study that showed a correlation between people hearing aircraft noise during the nighttime and having hypertension (high blood pressure). Moreover, Fyhri and Aasvang (2010) say that the cardiovascular system, affected by noise, could trigger the sympathetic nervous system during sleep.

Griefahn et al. (2008) did a study on the effects of noise while people are sleeping. Subjects were tested for four nights a week for three weeks. For three of the four nights, they were exposed to loud noises such as aircraft, railroads, or traffic. In contrast, one night of the four would be quiet. The researchers observed that after the nights when the subjects were exposed to high levels of noise, the subjects' heart rates were higher upon waking. Griefahn's team established a correlation between higher noise levels and impacts on heart rates.

Of the non-auditory effects of noise, disturbance during sleep is the biggest health concern. Fyhri and Aasvang (2010) state that this is the most serious concern with noise pollution, and it is what causes most of the people to complain about the high levels of noise. Stansfeld and Matheson (2003) stated that sleep disturbance had a higher chance of occurring when there were 50 or more peaks, or bursts, of noise 50 dB or greater during the night. Complementing the above statement, they also reported lower noise levels can increase how much Rapid Eye Movement (REM) sleep one receives, leading to heightened mental alertness throughout the next day.

Prashanth and Sridhar (2008) and Stansfeld and Matheson (2003) stated that there can be psychological effects of noise as well. These effects include mood changes, tension and edginess, and argumentative behavior. Daniel (2007) also noted additional psychological effects of noise possibly due to hearing loss, such as loneliness, isolation, and depression. Stansfeld and Matheson (2003) also reported that some people have complained of nausea, headaches, and anxiety; however, this could be due to other factors, including the occupational hazards and stress of the laborers surveyed.

Previous Public Perception Study

In 2006, CICAR conducted an in depth study on the public's opinion on environmental and community noise. They utilized a surveying company, Ipsos, who produced, distributed, and analyzed the surveys of the people. They found that 14% of the respondents said that noise was not an issue and 56% said that it was a slight issue. In other words, 70% of respondents were not very bothered by noise. Ipsos surveyed on several sources of noise and determined that traffic related noise sources were the major contributor and most annoying noise. From their responses, they inferred that Friday and Saturday were the noisiest days (Ipsos, 2006).

Ipsos determined that the people of Puerto Rico take little action to stop a noise source that bothers them and would rather modify their activity or lifestyle instead. One in eight people actually speak with the person making the noise and only 5% of people have actually called the police about a noise issue. Furthermore, only 1% of people have ever filed a noise complaint (Ipsos, 2006).

75% believe that the government is not doing everything possible to address the noise issue in Puerto Rico. The people believe that the government needs to create additional legislation, more strict enforcement, and educate the public about noise and its effects. Nine out of ten people rated the government's control of noise pollution as negative (Ipsos, 2006).

Noise Regulations in the United States and Puerto Rico

As long as there has been noise, governments and communities have tried to control or mitigate it. As Goines and Hagler (2007) noted, both the ancient Romans and Medieval European banned chariot usage at night to reduce noise levels while people were sleeping. Medieval Europeans also laid straw on chariot pathways to control noise levels. Communities today limit the hours of construction, refuse collection, or delivery services to reduce the annoyance levels.

Noise pollution was recognized by US government regulatory agencies as early as 1970, when industrial noise was regulated by the Department of Labor under the Occupational Standards and Hazard Act (Standards, 1971). When the impacts of noise began to be recognized as a form of pollution, the EPA was tasked with creating national regulations to address the issue. The newly-created Office of Noise Abatement and Control (ONAC), a division of the EPA, held a series of public hearings to gauge the prevalence of noise pollution across America. Transcripts of these hearings detail concerns on sources of noise such as transportation, construction, and agriculture, as well as comments on the physiological impacts (Control, 1972). In 1981, funding for the national program was cut, as the Reagan administration strove to decrease the federal budget (Shapiro, 1993). Furthermore, the benefits of noise regulation were highly localized to smaller regions (Shapiro, 1993), leading to the assertion that effective noise control regulations could be better implemented on a state and local level ("Noise Pollution", 2012).

Puerto Rico, with its rich natural resources, has had a proactive approach toward environmental protection. In 1970, then-Governor Luis A. Ferré signed the Environmental Public Policy Act of Puerto Rico, which created the JCA ("Historia de la JCA", 2010). The JCA was originally designed as an advisory board; however, after the EPA could no longer function as a regulatory noise agency, the JCA took on regulatory powers.

According to Alicea-Pou (2013), Puerto Rico has few noise regulations, and the regulations in place are rarely enforced. The "Regulation for the Control of Noise Pollution" (2011) enumerates the laws in place regarding noise pollution and enforcement. This report from the JCA contains definitions of devices and terms associated with noise pollution, general provisions on noise pollution, prohibited noises, acceptable noise emission levels, noise emission levels for motor vehicles and motorcycles on public right-of-ways, and administration of the regulations.

The JCA divides San Juan into four distinct zones for noise regulation purposes. Zone 1 focuses on residential areas and commercial dwellings (e.g. hotels). Zones 2 and 3 both concentrate on public areas; however, Zone 3 constitutes areas where high levels of noise are expected (e.g. loading docks). Zone 4 comprises quiet areas where noise levels should be low (e.g. hospitals).

The regulation discusses the means to determine noise levels and acceptable levels. Each zone has set limits for decibel levels for daytime and nighttime. Potentially excessive noise samples are measured in minimum half-hour increments; the offending noise cannot exceed the set limit of that zone for more than 10% of the recorded time. Exemptions are also discussed – for instance, a vehicular accident. The document additionally sets motor vehicle sound emission levels for both new and old vehicles. Testing procedures to measure sound levels of individual vehicles are laid out; notably, the test sensor must be located 50 feet from the right-of-way, and the vehicle must be traveling at the posted speed limit in order to get a good reading.

Finally, the JCA's report ("Regulation for the Control of Noise Pollution", 2011) specifies the requirements for the administration of all of these regulations. The regulation discusses compliance plans, dispensations, and penalties for violators.

All of the information featured in this chapter has explained what has been previously done in this field, and what is known about noise pollution. In the following chapter, we will discuss how we will further the understanding of noise pollution in San Juan, and also explore the perceptions of noise, as well as their alignment to current noise regulations.

Methodology

The fundamental purpose of this project was to help the Área de Control de Ruidos in furthering the completion of the *Action Plan Against Noise for Puerto Rico*. This was divided into two goals. The first goal of this project was to aid the ACR in further developing a clear understanding of the urban soundscape of San Juan. We met the first goal by accomplishing the following objective:

1. Collect and analyze sound data from different sites in San Juan to determine the temporal variability of sound.

The second goal of this project was to explore the perceptions of noise in San Juan and how the perceptions are aligned with the current noise regulations. We met the second goal by accomplishing the following objectives:

2. Investigate the public perception of noise at each site.
3. Analyze current noise regulations to determine if they address the public's opinions on noise.

Characterizing and Analyzing the Temporal Variability of Noise

Our first step in enhancing the JCA's understanding of the urban soundscape of San Juan was to establish a foundation of quantitative data for our project. In doing this, we also supplemented the JCA's existing sound information database. Though our sponsor had sound level data for 57 different sites in San Juan, the organization's records were several years old. More importantly, each site record only had data for 24 hours. Day-to-day variations were not accounted for in locations like schools or universities, which were much louder during the week than on the weekend, due to ongoing classes and increased traffic. Furthermore, the JCA already conducted previous studies that focused on noise pollution. However, no investigative team has yet conducted an urban soundscape research project of San Juan. Our project moves the JCA towards an urban soundscape study, which incorporates all aspects of sound, including noise as well as positive sounds.

Though it was not possible to study all 57 sites during our limited time in San Juan, we covered eight sites prioritized by our sponsor. The sites focused on in our project are listed in Table 1. The “Map Label” refers the designation of each site on the Google Map in Figure 3.

Station Code	Site Name	Site Location	Map Label
SJA2_02_1036	Parque Central	Side entrance to the Natatorium at the Parque Central on Ave. Kennedy.	B
SJA2_05_1100	Universidad de Sagrado Corazón	Front gate of the main campus of the Universidad de Sagrado Corazón.	A
SJA3_03_1228	Calle Cuba	Balcony of #520 Calle Cuba, at the intersection with Calle Guayama.	F
SJA4_06_0417	Calle 19	Front entrance to #1012 Urbano Villa Nevares, Calle 19.	C
SJA4_10_0714	Centro Médico	Balcony of #1055 Urb. Reparto Metropolitano, Calle 9 SE.	D
SJA5_08_0957	República de Colombia	Balcony of #86 Caparra Terrace, Calle 27 SE. Near the school República de Colombia.	H
SJA5_09_1134	Barbosa	Intersection of Ave. 65 Infantry and Ave. Barbosa.	G
SJA6_07_1872	Colegio Mizpa	Campus of Colegio Pentecostal Mizpa.	E

Table 1: Site Listing

Figure 3: Site Map (Generated by Google Maps)

After placing either a Larson Davis Model 831 or a Norsonic Nor121s at each site, the meters collected data continuously for seven days. During each day of data collection, one instantaneous decibel reading was collected every millisecond for 30 minutes. The devices were configured to record the 10th, 50th, and 90th percentiles of that 30-minute dataset, after which the devices discarded the unnecessary instantaneous decibel readings. At the end of the seven-day measurement period, each percentile list contained 336 data points. In the JCA's database, these values are also referred to as the L_{90}, the L_{eq}, and the L_{10}. The L_{90} is the 10th percentile of the decibel readings for the 30 minute interval, the L_{eq} is the median, and the L_{10} is the 90th percentile. The L_{90} is the value that is exceeded 90% of the time, thus making it the 10th percentile. The L_{eq} is the value that is exceeded 50% of the time, thus making it the median. The L_{10} is the value that is exceeded 10%, thus making it the 90th percentile. These percentiles provide an approximate representation of the sound levels in a particular area. The devices were placed in the shade to prevent overheating and were attached to poles or fences to protect from theft. Figure 4 demonstrates the described setup at República de Colombia. Appendix D shows the device setup at several sites.

Figure 4: República de Colombia, Site Setup

In order to gain a better understanding of the noise pollution, we needed to try to identify the sources and types of noise at each site. In order to do this, we visited each site for 30-minute intervals (the standard used in JCA noise regulations) throughout the week at different times of day. Our aim was to visit each site a total of 9 times, 3 times for the morning, afternoon, and evening. However due to limitations we were only able to visit each site 3-7 times in one week, choosing each day at random. During each visit, we used a sound meter to log sound level spikes above the ambient dB level, documenting the source of each spike and the peak dBs produced. A characterization of Centro Médico is visible in Figure 5. These levels were reported at the point of observation, not at the point of emission. Sources were identified by visual confirmation. The observations were made during morning, afternoon, and evening sessions. We aimed to record at least three times for every period of the day, which would have resulted in nine observations for each site. Due to time constraints, we weren't able to go as often as originally planned.

Figure 5: Centro Médico, Performing a Characterization

To record and analyze the sound level data, we needed to use sound meters that could gather statistical information on dB levels over the course of seven days. These devices would have to be durable, reliable, readily available, and cost-effective. Although other devices were considered, we used the Norsonic Nor121 noise analyzer (shown in Figure 6) and the Larson Davis Model 831 noise analyzer (shown in Figure 7), because the JCA already owned several of each. Further detailed technical specifications on these models are in Appendix C. The Larson Davis sound meter was the primary device used for both data collection and site characterization. The portability of the device greatly influenced our continued usage of the meter for site characterizations. The Nor121 was an older model of sound meter and was less portable, but was still useful for gathering seven-day data. Using multiple units of both models allowed us to cover more sites in the same time period. We chose to use the Nor121 and the Larson Davis Model 831 because they were readily available, already purchased and had the ability to accomplish what we needed.

The Nor121 was the primary noise analyzer used by the JCA for gathering information about noise pollution in the past. The Larson Davis 831 was used as well, especially when doing characterizations at the sites. Depending upon the installed software, the Larson Davis can also perform frequency analysis to help further evaluate sources of noise pollution.

Figure 6: Norsonic Nor121 in the field

Figure 7: Larson Davis Model 831 in the field

To confirm that our methods of data collection and analysis were valid, we interviewed local noise expert Sr. Jorge Rocafort, a professor of acoustics at UPR. He confirmed that we were using suitable equipment, and that our means to determine the major sources of noise were the best we could do, given the limitations of our budget and our time. Professor Rocafort also confirmed Alicea-Pou's statements on the largest contributors to noise pollution in San Juan.

Investigating Public Perceptions

To properly investigate the people's perception of sound we chose to administer surveys to the public of the areas where we collected data. We created surveys in both Spanish and English, with the help of the JCA, to determine the public's perceptions of the sound at the sites studied.

The sampling method that we used is a type of nonprobability sampling called convenience sampling. According to Berg and Lune (2011), convenience sampling relies on easily accessible or close at hand subjects. We interviewed Joseph Petrucelli, a statistics Professor at Worcester Polytechnic Institute, to determine a statistically significant sampling protocol and we found that "stratified sampling" would be ideal for this analysis. Stratified Sampling is a sampling technique in which an area is divided into subdivisions or strata and data are collected in each stratum independently. To properly use the stratified sampling technique with a set confidence interval, the population of each stratum must be known. Determining the population of these strata is impractical, due to each quadrant's constantly varying population. Although we could still use a stratified sampling technique without knowing population, the lack of knowledge of our confidence interval for the tendencies makes it unappealing. As such, we only surveyed those people we met at the sites. Since we looked for tendencies in the data because of our time constraints, rather than statistically significant results, we did not worry about sample size.

We asked the respondents to specify what they found to be the most annoying sources of noise in San Juan and then to rate how annoying they found each noise source. They were also asked how many days in an average week they noticed each source. Given that a soundscape consists of both positive and negative sounds, respondents were asked to list sources of sounds they found calming or pleasant and to rate how calming or pleasant they found each source. The respondents were then asked how many days in an average week they noticed these sounds. We also asked respondents if they had ever submitted a noise complaint and whether they were familiar with the process, if they were ever the subject of a noise complaint, and if they had ever been informed of the noise regulations in their community. Additionally, respondents were given lists of specific positive and negative sources of sound, and were asked to rate the sources. Finally, respondents were asked to rate the sound around them from 0-10, with 0 being very bad, 5 being neutral, and 10 being very good. Respondents were instructed to not answer any questions of which they are unsure, as we preferred a blank response, rather than a randomly-selected answer. The final list of questions is listed in Appendix B.

Along with conducting surveys at each site, the team also utilized an online survey creation, distribution, and analysis program called Survey Monkey. This program allowed us to administer surveys electronically to achieve a greater number of respondents, making our sampling more representative. Through this program, our sponsor sent our survey to his noise committee, and to anyone who was willing to take our survey.

Exploring the Representation of Public Opinion in Noise Regulations

We familiarized ourselves with the current noise regulations in San Juan. These regulations were written in Spanish but members of our team were able to translate it. We conducted an interview with our sponsor, Sr. Alicea-Pou, to learn more about current noise regulation enforcement. To get a better understanding of the creation and enforcement of noise regulations, we also conducted an interview with a local judge. Judge Ediltrudis Betancourt, of the municipal courts of San Lorenzo, further explained the regulations and the lack of enforcement of those regulations. After establishing a solid understanding of the current regulations and how they are enforced, we tabulated the responses that we received from the surveys and determined which sources of noise the public found most prominent. We compared the responses to the regulations to see if the public's opinions of noise were represented in the current regulations. Finally, we examined the process of enforcement to determine whether the current regulations were being adequately enforced.

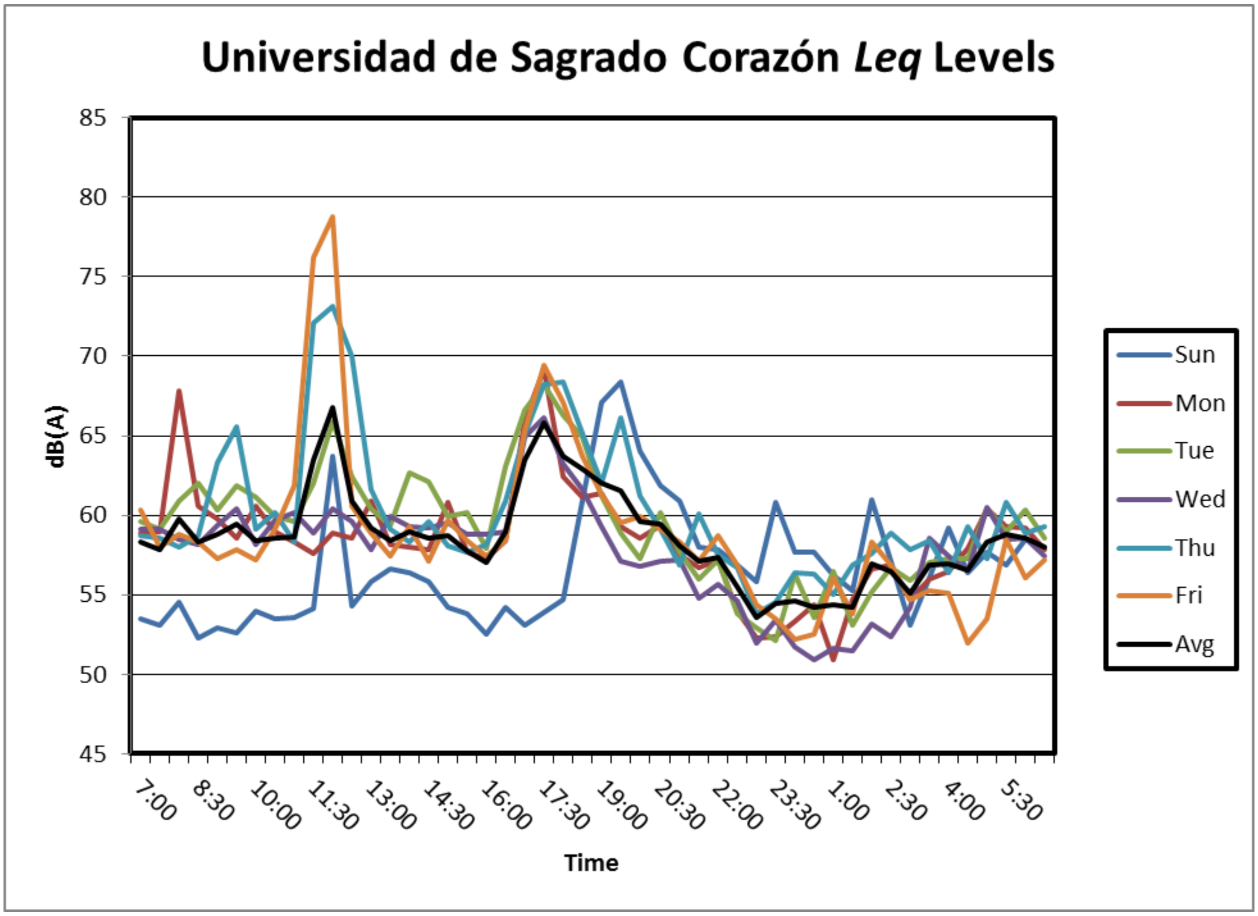
Results

This chapter presents our results of our study on noise pollution and urban soundscape of San Juan. We divided the material into two main subsections, Data Analysis, and Public Perceptions and Regulations. In the Data Analysis section, we examined the temporal variability and compared common sources of noise, as well as common sources of positive sounds, of each site. In the Public Perceptions and Regulations section, we analyzed our survey responses and compared their results to the government's current noise regulations.

Data Analysis

1. There was a great deal of temporal variability within each site.

Our project differs from some previous noise analyses performed in San Juan because we measured noise levels on a different time scale from past projects (Hodapp et al., 2007; Sansoucy et al., 2007; Tetreault et al., 2008). Furthermore, we also analyzed the soundscape using our collected noise level data and our survey responses. At eight sites we collected noise level data for seven days. Graph 1 shows the 50th percentile data for Universidad de Sagrado Corazón. The seven lines plotted each represent a full day's worth of data (the seventh line is the average of the L_{eq} values of all six days at each data point). For this graph, one day of data is missing because of equipment failure.



Graph 1: Universidad de Sagrado Corazón, L_{eq}

Missing or corrupted data occasionally was an issue with certain sites. Nevertheless, a great deal of temporal variability is apparent from the data collected. Appendix E contains all graphs showing the entire data spread which includes the 10th, 50th, and 90th percentiles for each of these sites.

Universidad de Sagrado Corazón was loud at certain key times throughout the day. The graph shows that Sunday has the lowest dB levels. It also shows Friday and Thursday as having high noise levels. There is a peak for all days around 12:00 pm. Since this site is a university, these peaks could be due to students who are leaving class and going to lunch. At around 5:00 pm every day, there was a peak of noise, most likely due to rush hour traffic, which we can infer from our characterizations of the site. From the hours of 10:00 pm to 6:00 am, we observed the lowest dB levels in this area. We believe that during these hours of the day, most people are asleep, resulting in less activity and noise. From our seven characterizations at Universidad de Sagrado Corazón, each for 30 minutes, we can infer that the causes of these spikes of noise are most likely traffic-related. Students and professors leaving and entering the University's parking lot, along with an occasional airplane flying overhead, caused most of the noise levels recorded. However, we cannot definitely state the exact causes of the noise spikes, as we were not present at the time the sound level meter was recording the data.

Time	AVG	STD	*CV*
11:30	63.5	8.7	13.8
12:00	66.8	7.7	11.5
6:00	58.6	1.4	2.4
6:30	58.0	0.8	1.4

Table 2: Universidad de Sagrado Corazón Selected *CV* values

The Coefficient of Variation (*CV*), is an indication of the amount of temporal variability of noise. The greater the *CV* value, the greater the temporal variability in relation to the rest of the dataset. Selected *CV* values for Universidad de Sagrado Corazón are in Table 2. The *CV* value of 13.8 and 11.5 at 11:30am and 12:00pm indicate a great deal of temporal variability between the noise levels in the days of the week. *CV* values of 2.4 and 1.4 at 6:00am and 6:30am are indicative of little variance of noise levels among the days of the week. This quantified data show trends of how the site behaves over a week, with relatively low *CV* values presenting evidence that the site's dB levels are consistent. High *CV* levels denote a chaotic time of the week, a period of time where the dB level varies greatly per day.

2. **Though each site had its own specific sound profile, determined by the seven-day data collection and the site characterizations, most sites showed common sources of sounds. This indicated certain noises and positive sounds are prevalent throughout the entire city.**

Some common sources of noise at the sites included various types of traffic, such as trucks (like the one seen in Figure 8), buses, and trains. Based on our site characterizations, we found these sources primarily at sites such as Barbosa, Centro Médico, and Universidad de Sagrado Corazón, resulting in a sound profile with high levels of noise. Centro Médico was similar to Barbosa, however, Centro Médico had more temporal variability. This is apparent when looking at a statistical summary of the *CV* values for both sites in Table 3. Centro Médico's lowest *CV* value was still over twice that of Barbosa, and Centro Médico also had a higher *CV* value for the mean, median, and maximum data points. Most likely, the greater temporal variability is due to Barbosa having a more constant source of noise. Centro Médico's sources of noise, such as the train and traffic, were also loud, but occurred more intermittently throughout the day.

Figure 8: Centro Médico, Truck

Centro Médico	Point of Interest	Barbosa
1.5	Min	0.7
4.1	Mean	3.0
4.3	Median	3.0
8.0	Max	6.9

Table 3: *CV* Statistical Comparison of Centro Médico and Barbosa

Some common positive sources of sound at the sites were birds and leaves rustling. These positive sources of sound occurred at sites such as República de Colombia and Calle 19 improving the sound profile. Calle 19 was relatively quiet, with little temporal variability in its sound profile. The major sources of noise were vehicles belonging to residents of the area.

Sites with higher noise levels, such as Barbosa and Centro Médico, experienced a common problematic phenomenon related to urban soundscapes. The issue is that noise sources, such as traffic, detract from the urban soundscape by not only adding negative sound to the area but by also being loud and disruptive. This results in positive sounds being inaudible, such as birds and trees rustling. This is particularly problematic in areas where the intent of the listener is to relax and hear calming positive sounds. One site that fits this description is Parque Central. In certain areas the noise pollution from traffic is so great that birds and a nearby babbling brook cannot be heard. Note that despite the differences in prevalence or location, vehicular noise and traffic were cited as the major noise sources in San Juan, confirming the original assertion in the Background chapter.

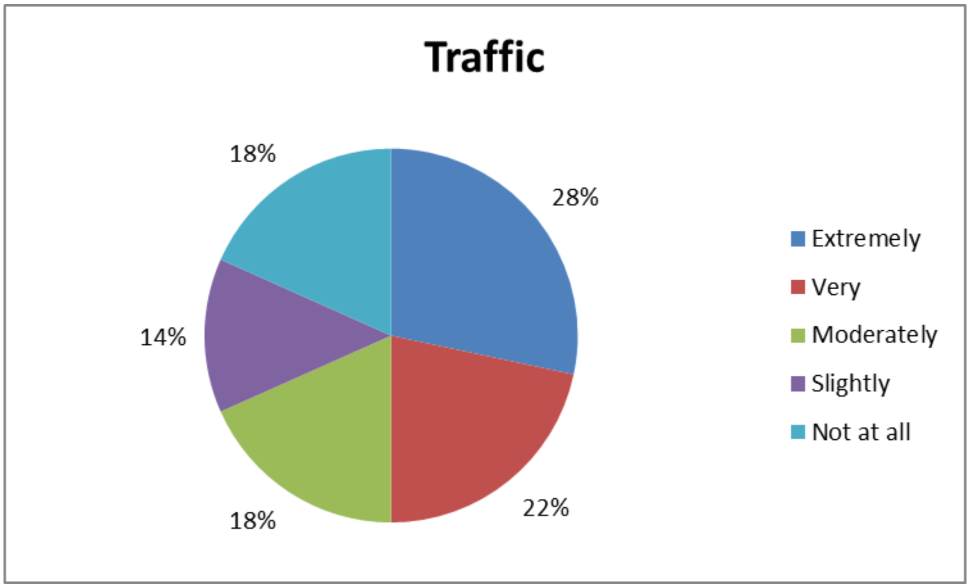
Public Perceptions and Regulations

Public perceptions were inferred from interviews with local experts and from our survey responses. We collected a total of 62 responses, gathered from the six sites where sound level data were recorded. Due to time constraints, we were not able to include Barbosa and República de Colombia in our survey analysis. Since Barbosa is a busy intersection, we reasoned that surveying at that site would yield few to no responses. We made the same conclusion for República de Colombia, due to its small population. The number of responses we received does not give a statistically accurate representation of San Juan, or even each specific site analyzed. They do, however, indicate tendencies of public perceptions and the data gathered will provide a foundation for more in depth studies.

Our online survey on Survey Monkey gained a lot of exposure, and accrued more than 300 responses. Since we were limited to a free account, we could only view the first 100 responses. Again, this number does not give a statistically significant representation of San Juan, and cannot be compared to sources at any given site, as the online survey did not ask for location information. However, tendencies within the responses can still provide a useful basis for inferences, as well as a foundation for further research.

3. **Looking at our survey results, only 32% of people viewed noise as a problem in their communities.**

To calculate this statistic, we included a question that gauged the respondent's perception of the sounds they hear. Respondents rated the sound around them on a scale of 0 to 10, where 0 were extremely bad sound levels and 10 were extremely good sound levels. 32% of respondents viewed the overall noise around them as negative, rating it 0,1,2,3, or 4. Further analysis found that 50%, 40%, and 27% of respondents indicated that traffic, sound amplification, and machinery, respectively, were "extremely" or "very" annoying to them. A full breakdown of survey responses for traffic is seen in Graph 2.



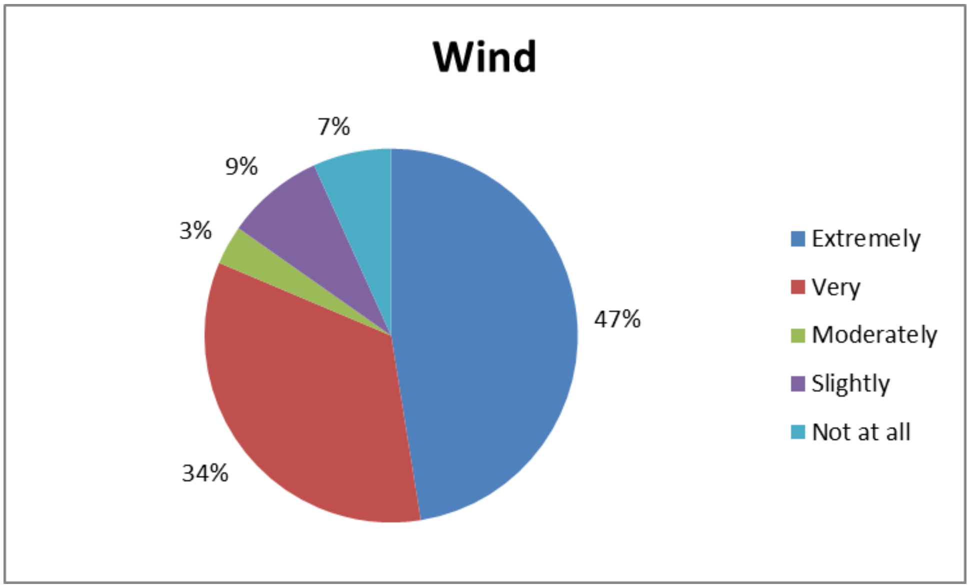
Graph 2: Survey Results, Traffic

To understand why 32% of respondents rated the sound around them as negative, we looked at their responses to a question wherein we asked them to rate how annoying sounds are, for example traffic and machinery. We looked at three sites: Universidad de Sagrado Corazón, Centro Médico, and Parque Central.

- For Universidad de Sagrado Corazón, 67% of respondents rated traffic as “very” or “extremely” annoying. 53% rated sound amplification as “very” or “extremely” annoying. 33% rated machinery as “very” or “extremely” annoying.
- For Centro Médico, 25% of respondents rated traffic as “very” or “extremely” annoying. 38% rated sound amplification as “very” or “extremely” annoying. 13% rated machinery as “very” or “extremely” annoying.
- For Parque Central, 50% of respondents rated traffic as “very” or “extremely” annoying. 54% rated sound amplification as “very” or “extremely” annoying. 42% rated machinery as “very” or “extremely” annoying.

4. From our survey responses, 47% said that the sound around them was pleasant or calming.

This was based on responses of the sound around them rated greater than 5. Going further with our survey analysis we found that 81%, 73%, 64%, and 72% of respondents indicated wind, birds, coquís, and water were “very” or “extremely” pleasant to them respectively. A full breakdown of survey responses for wind is seen in Graph 3.



Graph 3: Survey Results, Wind

- For Universidad de Sagrado Corazón, 93% of respondents rated wind as “very” or “extremely” pleasant. 87% rated birds as “very” or “extremely” pleasant. 93% rated coquís as “very” or “extremely” pleasant. 93% rated water sources as “very” or “extremely” pleasant.
- For Centro Médico, 63% of respondents rated wind as “very” or “extremely” pleasant. 38% rated birds as “very” or “extremely” pleasant. 57% rated coquís as “very” or “extremely” pleasant. 43% rated water sources as “very” or “extremely” pleasant.
- For Parque Central, 77% of respondents rated wind as “very” or “extremely” pleasant. 77% rated birds as “very” or “extremely” pleasant. 77% rated coquís as “very” or “extremely” pleasant. 67% rated water sources as “very” or “extremely” pleasant.

5. **Our online survey results confirm the tendencies in our site-specific surveys; however, differences in soundscape perceptions were also evident.**

From these responses, we could infer tendencies to compare with the site-specific surveys. General tendencies in both categories of survey were the same. 67% of respondents online viewed traffic as "very" or "extremely" annoying, and 93% of respondents online viewed wind as "very" or "extremely" pleasant. This supports our site-specific results, wherein 50% of respondents were "very" or "extremely" annoyed by traffic, and 81% of respondents were "very" or "extremely" pleased by wind.

On the whole, online respondents felt more strongly about both positive and negative sources of sound. Table 4 shows the percentages of respondents who answered "very" or "extremely" to each question of annoyance (for the negative sources) or calmness (for the positive sources). In all cases, the online responses were more passionate, and indicated a heightened state of awareness of the people surveyed concerning noise. This could be due to the sampling method involved for distributing the online survey.

Site-Specific	Source	Online
50%	Traffic	67%
40%	Sound Amplification	61%
27%	Machinery	41%
81%	Wind	93%
73%	Birds	92%
64%	Coquís	81%
72%	Water	89%

Table 4: Survey Response Comparison based on Given Sources

The Survey Monkey survey was an alternative method of perception-gathering that we used when site-specific surveys were less successful than originally anticipated. To quickly gain responses, our sponsor sent out the survey to an e-mail alias comprising members of a noise committee. In time, the survey reached a local chapter of the Sierra Club, an environmental advocacy group. Given that environmental activists would generally care more about the environmental consequences of excessive noise than the average person at a surveyed quadrant, it makes sense that the online responses would show more concern for sources of positive and negative sound.

6. From our survey analysis, the government's current noise regulations are not aligned with the public's opinions on noise.

From our survey analysis, the most commonly reported noise pollution concern for many people was traffic noise; however, after analyzing the noise regulations on file did not account for all aspects of traffic. Regulations on file were directed towards sound amplification and other sources of noise. According to current regulations, a car weighing more than 10,000 lbs must not exceed 86 dB while traveling at 35 mph or less. However, this sound pressure level must be measured 50 feet from the center of the right-of-way. This method does not work well in practice, wherein the streets are too narrow for the measuring reference point to be 50 feet away from the center of the road. Additionally, it is difficult or nearly impossible to isolate a single car's sound above the ambient levels of traffic and also measure that car's speed without additional equipment, to which we didn't have access. The regulation did not account for differing road surfaces, high traffic, or effective means of measuring noise and enforcing noise regulations of traffic.

We have found that noise is heavily regulated. From our investigations, there are three laws that have been established to control noise: Law 71, Law 155 and Law 416. These three laws (which are listed in Appendix H) encompass noise regulation and management in Puerto Rico. Laws 71 and 416 are very similar, as they both regulate unwanted sounds that prevent peaceful living. Both laws prohibit the use of car horns, alarms, sound amplification devices and noise from construction and industrial machinery. Law 416 also prohibits car racing, repairing, and testing in residential areas. Unlike Law 71, Law 416 highlights four different zones and states decibel limits for each zone during the day and night.

Law 155 regulates the use of speakers and other sound amplification equipment used to make public announcements. Users of such equipment must pay a tax of $60 to the Treasury of Puerto Rico per year for a license which legally allows them to operate this equipment. However, due to recent amendments, this tax is no longer required. The use of this equipment is generally prohibited between the hours of 10:00 pm and 8:00 am, unless the equipment is being used by the authorities. Failure to comply with this regulation will result in a $10 - $25 fine or one day in jail for each dollar owed for first time offenders, and a $50 - $100 fine or one day in jail per dollar owed for repeat offenders.

From our surveys, we have found that 44% of respondents are “very” or “extremely” annoyed by car horns, speakers, and other regulated sound amplification devices. However, 88% of all respondents stated that they have never submitted a noise complaint, and 83% of all respondents have never been informed of the noise regulations in their communities.

According to our surveys, noise from trains is an issue at Centro Médico. 1 in 4 respondents surveyed at Centro Médico listed trains as a source of annoying or irritating noise, and of those surveyed, the average response found trains “very” annoying. This was calculated by assigning sequential numerical values to each possible response to the survey question, and averaging the collected responses by those numerical values. The Centro Médico site and surveyed population were both located alongside the aboveground train tracks. As no noise barrier exists between the residential area and the train tracks (shown in Figure 9), residents are routinely exposed to high noise levels of approximately 70 dB, based on our characterization data. The current regulations do not address the train system, which means that this particular issue and the regulations do not coincide.

Figure 9: Centro Médico, Train (without barrier)

7. **From our survey analysis, the government's current noise regulations are not enforced in a way that effectively changes the public’s behaviors relating to noise.**

Although our research found heavy regulations on noise, as discussed in Finding 6, we also found that the enforcement of these regulations was lacking. According to Judge Ediltrudis Betancourt, the enforcement of noise in Puerto Rico suffers from several different factors, and it is ineffective in altering Puerto Rican’s behavior towards noise-related issues.

In an interview, Judge Betancourt explained the current noise enforcement system and pinpointed several issues, in her opinion, within the system. First, local police departments are unable to issue fines for minor noise violations. Under law, officers are only permitted to issue tickets of court appearance for noise violations. The current laws only allow courts and the Executive Board of the JCA to issue fines.

Second, the justice system often ignores noise-related issues. As she views the problem, this is due to a common misconception in Puerto Rico. In her opinion people view noise as a daily part of life and they do not think that noise has negative health effects. The Judge also went on to state that this directly has an effect on the police department's motivation to enforce noise. Beyond the officers' lack of motivation to write tickets for noise violations, many judges' personal views on noise often result in a reduced or revoked fine. This lack of enforcement for noise violation does not result in any change in Puerto Rican's behavior, and strengthened the misconception that noise in an unimportant issue.

Conclusions, Limitations, and Recommendations

Data Analysis

Conclusions

After completing the project, we found that there is a great deal of temporal variability of noise in San Juan. We studied temporal variability to understand the urban soundscape in order to advance completion of the noise action plan, so that the JCA can improve regulations and enforcement dealing with noise pollution. An example of this deals with the environmental impact study required by law to be completed before construction at a site. This study is performed by the construction company to predict their contribution to the pollution of the area, including noise pollution. For noise pollution, they have to monitor the site to determine the time when they would cause the least disturbance to perform construction. From our study of the temporal variability of noise pollution, the JCA will be more informed to regulate the noise pollution study needed to complete the environmental impact study.

We concluded that louder sites varied more in intensity over time than the quieter ones, largely due to traffic. From our data, the team concluded that weekends are typically the quietest days of the week, probably due to less traffic and activity occurring in each site. Also, we found that weekdays are typically the loudest days of the week, most likely due to increased work-week traffic. Finally, we concluded that of all the sounds we observed in San Juan, traffic noise had the most influence on the city’s soundscape.

At multiple sites we observed common sources of sound. The team found that the main source of sound at the louder sites was traffic and at the quieter sites, the predominant sounds were birds and rustling trees. We concluded that traffic negatively impacts the urban soundscape because it adds unpleasant sounds while simultaneously drowning out the predominantly pleasant sounds.

Limitations

Though our data collection was mostly successful, there were some limitations. We could only measure eight sites, due to time constraints. Additionally, some residents were reluctant to grant permission to have devices placed in their yards, making it harder to find enough sites for data collection. Due to the energy requirements of the devices, we also requested permission to plug the meters into electrical outlets at the homes of residents; this was not always available because of their concerns over monthly electrical bills. This detracted from the number of sites that could be investigated in the allotted time.

The sound meters had limitations as well. One of the Norsonic Nor121 meters overheated due to the heat and humidity and shut down, and we were unable to use this device. Due to occasional equipment failure, certain data collections were stopped prematurely. As a result, not every site has presentable data for seven days; some sites, such as Universidad de Sagrado Corazón or Centro Médico, only have data for six or even five days, respectively.

Although the devices were capable of recording audio continuously for seven days, which would have allowed us to identify the sources of sound, this optional feature was not implemented because additional software plug-ins were not installed. At best, we were able to make conjectures about possible likely sources. However, the characterizations were helpful in understanding the noise profile of the area, as it required us to visit the sites and gain firsthand knowledge of the sound sources in the area.

Transportation to the sites was an unexpected limitation in the project. The JCA only had a limited number of vehicles available for use, and several communication and organizational errors limited us in the number of times we were able to work in the field. Often, the team split into two subsets, only one of which could be seated in the vehicle to visit the sites for the day.

Recommendations

Complete statistical representation of San Juan.

The nature of our project has very broad implications. In order for our project to be a statistically significant representation of San Juan, data would have needed to be collected from about 95 sites using a 95% confidence interval, a 50/50 split and a 10% margin of error, which is a standard for any statistic study as mentioned by Professor Petruccelli. The findings from the eight sites we covered cannot be applied to all of San Juan. We recommend that the JCA continue seven day monitoring at the other sites to determine how San Juan's noise pollution acts throughout the city.

Further soundscape study.

Part of this project's purpose was to move the JCA, as a part of CICAR's development of a noise action plan, from a noise pollution study towards a soundscape study. We suggest a co-operative study with local experts at UPR, who have experience with research projects in the field of biodiversity monitoring and impacts of noise on animals. The methods for monitoring biodiversity could be adapted towards an urban soundscape study, incorporating the examination of sources of noise and positive sounds in the environment.

Paradigm shift.

We recommend a paradigm shift for future projects on noise pollution. We recommend shifting the focus from site-specific research to noise source-specific research. In site-specific research, the question to answer is "what is the environmental impact from noise at this site?" In source-specific research, the question to answer is "what is the environmental impact from this source?” Source-specific research is a better research model for a noise study in this area, particularly given the sources of noise present in Puerto Rico. From our site characterizations, we found that many sites are exposed to the same types of noise sources. Furthermore, certain sources of noise, such as planes, trains, and automobiles, are not necessarily localized to a specific location. Instead, they move from area to area, affecting multiple sites.

Source-specific research would involve audio recordings at locations that are then analyzed to determine the “population count” for a specific noise source, like cars. This can be adapted from UPR’s ABRIMON project, which investigates biodiversity and population counts of animals through automatic analysis of their calls. This study would take a longer time, but could ultimately be more useful. Instead of simply determining what noise levels are like at various sites across San Juan, the JCA could determine the impact from cars alone, or from trains alone, or from foot traffic alone. This would improve source-based regulations, as these data would show the effect from each source exactly.

Characterization protocols.

Proper identification of the sources of sound in noise pollution and soundscape studies is crucial. We propose that the JCA use their sound level meters to record audio of peaks of sound to characterize the site during the initial data-gathering period. The Larson Davis 831 could record the audio of the area if the sound meter measures a decibel level above a determined value. We suggest a value around 65 dB, as this will record the sound as the noise level approaches annoying, illegal, and potentially dangerous levels. Additionally, to move towards an urban soundscape study, we recommend an automated system of sound recording and analysis, similar to the ARBIMON [Automated Remote Biodiversity Monitoring Network] system developed at UPR for studying natural soundscapes. This automated system, when directed at urban soundscape, would allow a system of automated sound identification and data logging. This would be useful for determining the influence of noise in the urban soundscape, and how it negates and overlaps positive sounds.

Public Perception and Regulations

Conclusions

From the surveys distributed, we received a total of 62 responses from 6 sites. We were not able to survey two of our sites, mainly due to lack of an ideal population for surveying. Barbosa is located at a busy intersection, and surveying at that site would yield few to no responses. República de Colombia is a residential area with a small population; surveying would have been an inefficient use of time, given the expected number of surveys gathered at that site. Though the data we collected from our surveys were not statistically representative for all of San Juan, we were able to indicate tendencies in the public's perception.

We found that only 32% of our respondents viewed noise as a problem in their communities. However, we recorded high dB levels at many of our sites. Due to the adverse health effects of high levels of noise, we concluded that there needs to be more education and awareness about the issue of noise pollution in San Juan.

To calculate this statistic, we included a question that gauged the respondent's perception of the sound around them. Respondents rated the sound around them on a scale of 0 to 10, where 0 were extremely bad sound levels and 10 were extremely good sound levels. Furthermore, we analyzed other survey questions to see if they rated given sources of noise as "extremely" or "very" annoying. 50% of all respondents ranked traffic as either "extremely" or "very" annoying. This finding supports our hypothesis that traffic has the most influence on the urban soundscape of San Juan. 40% of all respondents stated that they were "very" or "extremely" annoyed by sound amplification devices. From our initial characterizations in the city, we found that sound amplification is prevalent, and our survey responses confirm this finding.

In order to understand the soundscape of San Juan, we also determined which respondents said the sound around them was calming. We found that 47% of respondents rated the sound a 6 or higher on the 0-10 scale described above. Other survey questions asked if respondents found given sources of sound calming or pleasant. Analysis of these responses found that most people surveyed viewed birds, wind, coquís, and sources of water (including rain, fountains, and waves) as “very” or “extremely” calming.

These tendencies in both positive and negative source perception could be due to any number of reasons, including the order of the questions asked on the survey, the wording of positive and negative questions on the survey, the randomness of the surveyed population, the particular sounds prevalent at the sites the day the surveys were taking place, the active or passive listening of the respondents, or even other variables not considered in this study.

These distinctions in questions asked, question order, wording, and particularly randomness are also echoed in the Survey Monkey responses. 67% of respondents online viewed traffic as “very” or “extremely” annoying, and 93% of respondents online viewed wind as “very” or “extremely” pleasant. This supports our site-specific results, wherein 50% of respondents were “very” or “extremely” annoyed by traffic, and 81% of respondents were “very” or “extremely” pleased by wind. The tendency of the online respondents to have stronger feelings on both positive and negative sources of noise may be linked to the lack of randomness in the surveyed population. The Survey Monkey online questionnaire was originally distributed to members of a noise committee e-mail list. Members were encouraged to share it with friends; presumably, these friends would also be aware of noise pollution issues and other environmental concerns, potentially skewing the results toward stronger responses. Eventually, we were notified that our online survey had been distributed to members of the local chapter of the Sierra Club, a well-known environmental advocacy group. Given that environmental activists would generally be more aware of environmental consequences of excessive noise than the average person at a surveyed quadrant, it is reasonable to expect that the online responses would show stronger opinions on sources of positive and negative sound.

The team also analyzed the noise regulations currently in place. We found that the regulations are not effectively addressing the public's noise opinions. As stated before, traffic is the most prevalent sound in the city; however, the current regulations do not address all aspects of traffic. Differing road surfaces, which can increase traffic noise levels, are not accounted for in the current regulations. Many respondents stated that they are bothered by speakers and other regulated sound amplification devices. However, 88% of all respondents stated that they have never submitted a noise complaint, and 83% of all respondents have never been informed of the noise regulations in their communities. From this finding, we concluded that the government is not sufficiently raising the awareness of noise regulations. Finally, only 1 in 4 respondents at Centro Médico stated that they are bothered by the train, which is not regulated. Although the majority of respondents did not indicate that the train was a source of irritation or annoyance, the train produced noise levels at or above 70 dB (see Appendix F). Given these high noise levels, regulations should be made, but are not currently in place.

We found that the current regulations are not being enforced effectively. According to Judge Ediltrudis Betancourt, noise enforcement suffers from several issues. She stated that police officers are not motivated to deal with noise complaints, as they can only issue court appearances. Many of these court cases are dismissed due to insufficient evidence, as the court often requires the officer to present a decibel reading proving that the accused has violated the regulations.

The judge also stated, contrary to her opinion, that community members view noise as a daily part of life, and that they believe noise has no associated health risks. From her point of view, she stated that some judges will not mediate noise related cases because they deem these cases as unimportant. As a result, this lack of enforcement will only exacerbate the noise pollution problem, and the public's attitudes towards noise will not change.

Limitations

Due to time constraints in both visiting each site and in the weeks to complete the project, as well as the limited transportation previously discussed, we couldn't get enough people to take the surveys in order to be statistically significant for the area. We were further limited in trying to determine statistical significance, as the population (and thus sample size) of each quadrant was unknown.

Furthermore, we were limited by the language barrier, which created difficulties in translating the survey into Spanish, as well as administering the survey to the public. We were limited in the number of people that could easily distribute surveys to a non-English-speaking population. This ultimately limited the number of surveys we were able to collect, and reduced the applicability of any tendencies from the survey data to the population of San Juan. We mitigated this limitation with the help of one fluent speaker on the team and two government employees.

The online survey presented a number of previously unforeseen limitations. As we did not anticipate using an online survey, we did not perform any sort of cost-benefit analysis to determine which survey host to use or whether we should purchase a full account with the host. We only realized after beginning to create the Survey Monkey questionnaire that it was limited to ten questions and 100 responses. As such, we had to remove questions from the survey that had already been distributed at specific sites. The site-specific survey questions were based on Ipsos' 2006 study, ISO standards, and past WPI projects. After our online survey was distributed, we received more than 300 surveys. However, the free account only allowed us to view the first 100 submissions, meaning we were limited to analyzing less than 33% of our collected responses. The inability to export responses to Microsoft Excel hindered our full analysis of user-submitted sources of positive and negative sounds. We could only compare the questions wherein we had given respondents a set list of sources and asked them to rate those. Both the site-specific survey questions and the online survey questions are in Appendix B.

Recommendations

Improved local noise enforcement.

We recommend allowing local police departments to issue fines on noise violations, as well as requiring all officers to carry sound level meters to quantify those violations. Currently, police are only permitted to ticket violators with notices of municipal court appearances. Proof of excessive noise emission is not required for this ticket. However, municipal court judges will often request evidence in the form of decibel level readings. When this evidence cannot be produced, the local noise violations are often ignored. Alternatively, we recommend to change how noise is regulated in Puerto Rico, shift legislation away from decibel levels, and propose new laws based on audible sound, similar to how noise is dealt with in other communities on a local level.

Sound perception survey.

We recommend that a statistically significant survey be conducted to accurately capture the public's views regarding sound. While determining if the current regulations addressed the public's noise opinions, we found there were certain annoying sources that were not represented in the regulations. Therefore, we recommend a more in-depth study that will result in more accurate public opinion data. This data will then be usable in soundscape evaluation and noise regulation legislation and revision. This study can be similar to the Ipsos study in 2006; however, a larger focus on soundscape, and not just sources of noise pollution, would be beneficial.

We recommend that the JCA purchase a full license for an online survey. This would allow full view of all individual survey responses, unlimited questions, easier formatting for user-submitted sources (and use of the same user-submitted text in later questions), and exportable survey responses for a more complete statistical breakdown. For the survey we distributed, more questions would have allowed us to learn more about people's perceptions of positive and negative sources of sound, as well as noise regulations. Furthermore, as our online survey received more than 300 responses, but we could only analyze the first 100 responses, we were including less than 33% of our total data for online surveys.

Had we known that we were going to use a Survey Monkey online questionnaire, we would have originally designed our survey with different questions. Assuming that would have been a paid account, and we would not have been limited to only 10 questions, we could have asked more about noise regulations and public perceptions of other specific sources of noise. As a larger study would not be as site-specific, the lack of location data in an online survey response would not be a limitation. Given the fees associated with a full-featured account on SurveyMonkey.com or similar websites, a cost-benefit analysis should also be performed, to determine the best host for an online survey.

Culture study.

According to Judge Ediltrudis Betancourt of the municipal courts of San Lorenzo, and Professors Nirzka Labault, Victor Reyes, and Jorge Rocafort of UPR, Puerto Rico has a very loud culture. According to Professor Rocafort, since Puerto Rico has a warm climate year round, the residents are often outside at all times of the day and night. This results in music and loud voices throughout the day, causing noise disturbances. We did not have the time to complete a culture study along with the soundscape and noise pollution studies we were focusing on. Thus, we recommend that a complete culture study be done, as it could explain why Puerto Rico tends to be very loud and may help to improve regulations and their enforcement. This would include conducting several interviews and forming a foundation of extensive culture research. The study could also explain why certain noises are being created and how to mitigate them. Also, the study could help to determine why the residents interpret noise the way they do. Most do not see it as a serious issue. According to Judge Betancourt, she believes that noise is a health issue and should be considered a serious concern.

Noise mitigation through construction of noise barriers.

Our characterizations at Centro Médico showed high noise levels due to the passing train. In an interview, Professor Rocafort discussed the possibility of noise dampening and blocking materials for indoor and outdoor use. We recommend that in areas of very high noise level, the government construct a noise barrier to absorb some of the excessive sound. While Coensel et al. (2009) stated that railway noise is less annoying than road traffic noise at the same average sound intensity level, our findings revealed that noise from the train was more intense and had a higher dB reading than noise from traffic. Therefore, we propose that a concrete wall should be constructed along the train tracks to mitigate the noise from the train. We also suggest that natural sound barriers, such as trees and bushes, could be implemented as well to both reduce noise and also improve the environment.

Final Summary

The study of noise pollution and urban soundscape requires a multidisciplinary approach. It establishes a link between technology and society because of the technical data of sound levels compared to the public's perception of sound. The evaluation of the regulations and enforcement of noise further solidifies this link, as the laws are based off of decibel levels but need more input from the human perspective. This is an issue not just isolated to San Juan, but is a global issue as well.

In conclusion, we found that there was temporal variability of noise at the locations we studied. Weekends were generally quieter, and weekdays were generally louder, possibly due to the major noise source common at the sites. The major sources of noise that we deduced from our characterizations and survey responses were traffic, sound amplification, and machinery. The major positive sources of sounds that we concluded from our characterizations and survey responses were wind, birds, coquís, and sources of water. The current regulations and laws need to be revised, as they do not adequately represent the public's perception of the sound in San Juan. We found that most of the Puerto Rican people viewed their soundscape as positive, whereas the noise data collected indicate a noisy environment, suggesting a possible unique socio-cultural attitude towards noise.

To aid further noise and urban soundscape studies in gathering more quantitative and qualitative data we recommend:

- Complete statistical representation of San Juan
- Further soundscape study

- Paradigm shift from decibel levels to sources of sound
- Additional characterization protocols

To aid in regulations’ revisions and enforcements as well as a better interpretation of the Puerto Rican people’s response to noise we recommend:

- Community noise enforcement at local level by police
- Culture study relating to noise
- Further public’s awareness of noise analysis
- Noise education
- More revised regulations based on the public’s opinion

To help with the urban noise issue of San Juan we recommend artificial and natural sound barriers to mitigate noise.

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Appendix A: Interview Questions

Acoustic Expert (e.g. Professor of Acoustics)

1. What is your occupation?
2. How long have you been working in the field of acoustics?
3. What are the different types of noise and what are the characteristics of each type? Which of these types are specific to San Juan?
4. What do you think are the biggest contributors to noise in the San Juan area? Can you elaborate on this (loudest sounds, sounds that last the longest, etc)
5. We have noticed that some people like to play their music loudly. Is playing music loudly normal and on average how often do you hear loud music?
6. Do you think the levels of noise occurring in San Juan have negative impacts on the residents? Why?
7. Do you have suggestions of how to reduce the noise in areas of high concern? Do you think that the government can do more to reduce noise?
8. Do you think that the city's architecture promotes noise? (The spacing of the buildings from the street, the cobblestone streets of Old San Juan, building materials used to construct buildings)
9. What are the different types of equipment of measuring noise? What are the advantages and disadvantages of each?
10. We plan to measure noise with the Norsonic 121 and the Larsen Davis 831. Also, we want to use these devices to measure noise continuously for 7 days and then extract data every 30 minutes. This data includes the L_{eq}, L_{10}, L_{90}. Is this a good representation of the data? How can we improve our measurements?

Government Agent within CICAR

1. How many noise complaints do you receive in an average week? Year?

2. What times of the day/week/year do people make the most complaints?
3. Where in the noise control hierarchy does the JCA fall?
4. Are there other noise control agencies in Puerto Rico that operate on more local level?
5. What is the process after someone makes a noise complaint?
6. What exactly is the noise action plan? What is the expected outcome? How many agencies are currently involved? Why are the airport authorities not involved?
7. Why are Laws 71 and 416 different?
8. Is Law 155 still in effect
9. Are there regulations on the train system? Why is there so much grinding/screeching? Is this due to faulty tracks or a lack of maintenance?
10. Do you think the penalties for violating noise regulations should be increased?
11. How close to completion is the noise action plan in your opinion? What do you think is missing from it?
12. How many meetings are held to discuss the noise action plan?
13. Does the JCA have different offices in other areas of PR?
14. Does there need to be more education of the public on now? How would you educate them?
15. Is there anything else that we should ask?

Legal Expert (e.g. Judge)

1. If one wants to implement a new regulation, what procedure must he follow?
2. Is Law 155 still in effect?
3. How many noise-related court cases have you dealt with?
4. Of these court cases, is there a common factor, e.g. are people complaining about a particular noise?

5. Do you think the penalties for violating noise regulations should be increased or decreased? Why/why not?
6. How closely do you work with the JCA and other noise regulations agencies? How often is a noise related issue brought to your attention? What is usually your response to these issues?
7. How close to completion is the noise action plan in your opinion? What do you think is missing from it?
8. Do you have suggestions of how to reduce the noise in areas of high concern? Do you think that the government can do more to reduce noise?

Appendix B: Survey Questions

Site-Specific Survey [English]

Hello. We are a group of students from Worcester Polytechnic Institute working with the Noise Control Area of the Environmental Quality Board studying soundscape and noise pollution in San Juan. As part of our investigation, we are surveying residents and tourists in San Juan to determine the public opinion on noise in the city. All responses are completely anonymous. Demographic information is requested only for the purposes of post-survey analysis. If you are unsure or uncomfortable answering any question, please leave the question blank. This survey is expected to take around 10-15 minutes to complete. Thank you in advance for your time.

Date: ______________ Time: ____:____ ☐ AM ☐ PM

1. Are you a full-time resident of Puerto Rico? ☐ Yes ☐ No
2. What is your gender? ☐Male ☐ Female ☐ Other
3. In which age group do you fall? ☐13-17 ☐ 18-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56+
4. In no specific order, please list the biggest sources of sound that you dislike in this area. Feel free to use none, some, or all of the spaces provided.

Source 1:
Source 2:
Source 3:
Source 4:
Source 5:

5. Thinking about the last 12 months or so, how much does sound from each source listed in question 4 bother, disturb, or annoy you?

Source	Not at all	Slightly	Moderately	Very	Extremely
Source 1	☐	☐	☐	☐	☐
Source 2	☐	☐	☐	☐	☐
Source 3	☐	☐	☐	☐	☐
Source 4	☐	☐	☐	☐	☐
Source 5	☐	☐	☐	☐	☐

6. How many days in an average week do you notice each source listed in question 4?

Source	0-2 days	3-4 days	5-7 days
Source 1	☐	☐	☐
Source 2	☐	☐	☐
Source 3	☐	☐	☐
Source 4	☐	☐	☐
Source 5	☐	☐	☐

7. In no specific order, please list the biggest sources of sound that are pleasant or calming in this area. Feel free to use none, some, or all of the spaces provided.

Source 1:
Source 2:
Source 3:
Source 4:
Source 5:

8. Thinking about the last 12 months or so, how much do you find the sources of sound from question 7 calming or pleasant?

Source	Not at all	Slightly	Moderately	Very	Extremely
Source 1	☐	☐	☐	☐	☐
Source 2	☐	☐	☐	☐	☐
Source 3	☐	☐	☐	☐	☐
Source 4	☐	☐	☐	☐	☐
Source 5	☐	☐	☐	☐	☐

9. How many days in an average week do you notice each source listed in question 7?

Source	0-2 days	3-4 days	5-7 days
Source 1	☐	☐	☐
Source 2	☐	☐	☐
Source 3	☐	☐	☐
Source 4	☐	☐	☐
Source 5	☐	☐	☐

10. Have you ever submitted a noise complaint? ☐ Yes ☐ No
11. Are you familiar with the process to make such a complaint? ☐ Yes ☐ No
12. Has someone ever made a noise complaint against you? ☐ Yes ☐ No
    If yes, what was the outcome? ☐ Warning ☐ Court appearance ☐ Fine
13. Have you ever been informed of the noise regulations in your community? ☐ Yes ☐ No

14. Thinking about the last 12 months or so, how much does noise from each source listed below bother, disturb, or annoy you?

Source	Not at all	Slightly	Moderately	Very	Extremely
Traffic (Buses, Cars, Trucks)	☐	☐	☐	☐	☐
Sound Amplification (Speakers, Festivals, Public Events, Religious Events)	☐	☐	☐	☐	☐
Machinery (Air Conditioners, Generators)	☐	☐	☐	☐	☐

15. Thinking about the last 12 months or so, how much do you find the following sources of sound pleasant or calming?

Source	Not at all	Slightly	Moderately	Very	Extremely
Wind (Rustling of trees and bushes)	☐	☐	☐	☐	☐
Birds	☐	☐	☐	☐	☐
Coquís	☐	☐	☐	☐	☐
Sources of Water (Fountains, Ocean, Rivers)	☐	☐	☐	☐	☐

16. How would you rate the sound around you on a 0 to 10 scale? (0 being very bad, 5 being neutral, 10 being very good)?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐9 ☐ 10

Thank you for your participation in this survey. If you have any questions or comments about your survey results, please contact us at noise@wpi.edu.

Site-Specific Survey [Spanish]

Hola. Somos un grupo de estudiantes del Instituto Politécnico de Worcester apoyando al Área de Control de Ruidos de la Junta de Calidad Ambiental para estudiar la problemática de ruido ambiental en San Juan. Como parte de nuestro estudio sobre el perfil sonoro comunitario, estamos encuestando a residentes y turistas en su área para determinar la opinión pública sobre el nivel de sonido en la ciudad. Todas las respuestas son completamente anónimas. La información demográfica se solicita solamente para el análisis por grupo de encuestados. Este cuestionario puede tardar 10-15 minutos. Agradecemos que complete en su totalidad este cuestionario.

Fecha: ______________ Hora: ____:____

1. ¿Es usted un residente de Puerto Rico? ☐ Sí ☐ No
2. ¿Cuál es su género? ☐ Hombre ☐ Mujer ☐ Otro
3. ¿En qué grupo de edad cae usted? ☐ 13-17 ☐ 18-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56+
4. En ningún orden específico, indique los principales tipos de sonidos que escucha en la zona que usted reside. Puede utilizar ninguno, algunos, o todos los espacios proporcionados.

Tipo de sonido 1:
Tipo de sonido 2:
Tipo de sonido 3:
Tipo de sonido 4:
Tipo de sonido 5:

5. Tomando en consideración los últimos 12 meses, indique el grado de molestia o perturbación causada por cada tipo de sonido mencionado en la pregunta 4.

Tipo de Sonido	Absolutamente nada	Ligeramente	Medianamente	Mucho	Extremadamente
Sonido 1	☐	☐	☐	☐	☐
Sonido 2	☐	☐	☐	☐	☐
Sonido 3	☐	☐	☐	☐	☐
Sonido 4	☐	☐	☐	☐	☐
Sonido 5	☐	☐	☐	☐	☐

6. ¿Cuantos días de la semana observa usted cada tipo de sonido indicado en pregunta 4?

Sonido	0-2 días	3-4 días	5-7 días
Sonido 1	☐	☐	☐
Sonido 2	☐	☐	☐
Sonido 3	☐	☐	☐
Sonido 4	☐	☐	☐
Sonido 5	☐	☐	☐

7. En ningún orden en particular, por favor indique las tipos de sonidos que son agradables para usted en esta área. Puede utilizar ninguno, algunos, o todos los espacios proporcionados.

Tipo de sonido 1:
Tipo de sonido 2:
Tipo de sonido 3:
Tipo de sonido 4:
Tipo de sonido 5:

8. Tomando en consideración los últimos 12 meses, indique cuanto le agrada cada tipo de sonido mencionado en la pregunta 7.

Tipo de Sonido	**Absolutamente nada**	**Ligeramente**	**Medianamente**	**Mucho**	**Extremadamente**
Sonido 1	☐	☐	☐	☐	☐
Sonido 2	☐	☐	☐	☐	☐
Sonido 3	☐	☐	☐	☐	☐
Sonido 4	☐	☐	☐	☐	☐
Sonido 5	☐	☐	☐	☐	☐

9. ¿Cuantos días de la semana observa usted cada tipo de sonido indicado en pregunta 7?

Sonido	**0-2 días**	**3-4 días**	**5-7 días**
Sonido 1	☐	☐	☐
Sonido 2	☐	☐	☐
Sonido 3	☐	☐	☐
Sonido 4	☐	☐	☐
Sonido 5	☐	☐	☐

10. ¿Alguna vez ha presentado una queja por ruido ambiental en su comunidad?
☐ Sí ☐ No
11. ¿Está familiarizado con el proceso de hacer esa denuncia? ☐ Sí ☐ No
12. ¿Alguna vez alguien ha hecho una querella en su contra por ruidos? ☐ Sí ☐ No
Si es sí, ¿cuáles fueron las consecuencias?
☐ Aviso ☐ Comparecencia ante el tribunal ☐ Multa
13. ¿Alguna vez ha sido informado de las regulaciones de ruido en su comunidad?
☐ Sí ☐ No

14. Tomando en consideración los últimos 12 meses, indique el grado de molestia o perturbación de los siguientes tipos de sonidos.

Tipo de Sonido	**Absolutamente nada**	**Ligeramente**	**Medianamente**	**Mucho**	**Extremadamente**
Tráfico (autobuses, coches, camiones)	☐	☐	☐	☐	☐
La amplificación de tipo de sonido(altavoces, Festivales, eventos públicos, eventos religiosos)	☐	☐	☐	☐	☐
Maquinaria (acondicionadores de aire, generadores)	☐	☐	☐	☐	☐

15. Tomando en consideración los últimos 12 meses, indique cuanto le agrada los siguientes tipos de sonido.

Tipo de Sonido	**Absolutamente nada**	**Ligeramente**	**Medianamente**	**Mucho**	**Extremadamente**
Viento (el susurro de los árboles y arbustos)	☐	☐	☐	☐	☐
Pájaros	☐	☐	☐	☐	☐
Coquís	☐	☐	☐	☐	☐
Agua (tipos, océano, ríos)	☐	☐	☐	☐	☐

16. ¿Cómo calificaría el sonido a tu alrededor usando la escala de 0 a 10 (0 es muy malo, 5 es neutro, 10 es muy bueno)?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐9 ☐ 10

Gracias por su participación en esta encuesta. Si tiene algún comentario o inquietud sobre los resultados de la encuesta, por favor mande un mensaje electrónico a noise@wpi.edu.

Online Survey [Spanish]

Encuesta de Opinión sobre Acustica Ambiental en Puerto Rico

Somos un grupo de estudiantes del Instituto Politécnico de Worcester colaborando con el Área de Control de Ruidos de la Junta de Calidad Ambiental en un estudio sobre la problemática de ruido ambiental en San Juan, Puerto Rico. Como parte de nuestro proyecto de investigación sobre el ruido urbano, estamos encuestando a residentes de Puerto Rico para conocer su opinión sobre los ruidos ambientales en la comunidad donde residen.

El cuestionario es anónimo y no tiene que proveer ninguna información personal de usted, ni donde reside. La información demográfica se solicita solamente para el análisis por grupo de encuestados. Agradecemos que complete en su totalidad este cuestionario. Solo le tomara uno pocos minutos y su contribución será de gran utilidad en nuestro proyecto e informe final.

Para más detalles de esta iniciativa y los resultados se puede comunicar con el Área de Control de Ruidos de la JCA al (787) 767-8181 ext. 3207 o por correo electrónico a JoseAliceaPou@JCA.Gobierno.pr.

1. ¿En qué grupo de edad cae usted? ☐ 13-17 ☐ 18-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56+
2. En ningún orden específico, indique los principales tipos de sonidos que escucha en la zona que usted reside. Puede utilizar ninguno, algunos, o todos los espacios proporcionados.

Tipo de sonido 1:
Tipo de sonido 2:
Tipo de sonido 3:
Tipo de sonido 4:
Tipo de sonido 5:

3. Tomando en consideración los últimos 12 meses, indique el grado de molestia o perturbación causada por cada tipo de sonido mencionado en la pregunta 2.

Tipo de Sonido	**Absolutamente nada**	**Ligeramente**	**Medianamente**	**Mucho**	**Extremadamente**
Sonido 1	☐	☐	☐	☐	☐
Sonido 2	☐	☐	☐	☐	☐
Sonido 3	☐	☐	☐	☐	☐
Sonido 4	☐	☐	☐	☐	☐
Sonido 5	☐	☐	☐	☐	☐

4. ¿Cuantos días de la semana observa usted cada tipo de sonido indicado en pregunta 2?

Sonido	0-2 días	3-4 días	5-7 días
Sonido 1	☐	☐	☐
Sonido 2	☐	☐	☐
Sonido 3	☐	☐	☐
Sonido 4	☐	☐	☐
Sonido 5	☐	☐	☐

5. En ningún orden en particular, por favor indique las tipos de sonidos que son agradables para usted en esta área. Puede utilizar ninguno, algunos, o todos los espacios proporcionados.

Tipo de sonido 1:
Tipo de sonido 2:
Tipo de sonido 3:
Tipo de sonido 4:
Tipo de sonido 5:

6. Tomando en consideración los últimos 12 meses, indique cuanto le agrada cada tipo de sonido mencionado en la pregunta 5.

Tipo de Sonido	Absolutamente nada	Ligeramente	Medianamente	Mucho	Extremadamente
Sonido 1	☐	☐	☐	☐	☐
Sonido 2	☐	☐	☐	☐	☐
Sonido 3	☐	☐	☐	☐	☐
Sonido 4	☐	☐	☐	☐	☐
Sonido 5	☐	☐	☐	☐	☐

7. ¿Cuantos días de la semana observa usted cada tipo de sonido indicado en pregunta 5?

Sonido	0-2 días	3-4 días	5-7 días
Sonido 1	☐	☐	☐
Sonido 2	☐	☐	☐
Sonido 3	☐	☐	☐
Sonido 4	☐	☐	☐
Sonido 5	☐	☐	☐

8. Tomando en consideración los últimos 12 meses, indique el grado de molestia o perturbación de los siguientes tipos de sonidos.

Tipo de Sonido	**Absolutamente nada**	**Ligeramente**	**Medianamente**	**Mucho**	**Extremadamente**
Tráfico (autobuses, coches, camiones)	☐	☐	☐	☐	☐
La amplificación de tipo de sonido(altavoces, Festivales, eventos públicos, eventos religiosos)	☐	☐	☐	☐	☐
Maquinaria (acondicionadores de aire, generadores)	☐	☐	☐	☐	☐

9. Tomando en consideración los últimos 12 meses, indique cuanto le agrada los siguientes tipos de sonido.

Tipo de Sonido	**Absolutamente nada**	**Ligeramente**	**Medianamente**	**Mucho**	**Extremadamente**
Viento (el susurro de los árboles y arbustos)	☐	☐	☐	☐	☐
Pájaros	☐	☐	☐	☐	☐
Coquís	☐	☐	☐	☐	☐
Agua (tipos, océano, ríos)	☐	☐	☐	☐	☐

10. ¿Cómo calificaría el nivel de sonido ambiental en esta zona usando la escala de 1 a 10 (1 es muy bajo, 10 es muy alto)?
    ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐9 ☐ 10

Appendix C: Technical Data

Nor121 Specification Data

Overall Performance

- The overall performance of the Nor-121 with a suitable microphone and preamplifier, corresponds to the Sound Level Meter Standards IEC 60651 Type 1, IEC 60804 Type 1, ANSI S 1.4 - 1983 Type 1 and ANSI S1.43 - 1997 Type 1. (Type 0 with suitable microphones) The filter characteristics meet Filter Standard IEC-61260 class 1 for analogue and digital filters as well as the ANSI S 1.11 - 1986 Type 1D
- Dimensions: (W×H×D) 36×5,5×20 [cm], 36×6,5×20 [cm] with feet
- Weight: 2,9 kg with battery
- Power Level: 9001 kDks, in accordance with ANSI S 1.4 - 1983 Type 1

Analogue Inputs

- No. of channels: 1 (optionally 2)
- Microphone input: 7-pin LEMO connectors
- Preamplifier voltage: ±20V, 3mA
- Polarisation voltage: 0 or 200V selectable, ±1%
- Input impedance: >1Mohm/<200pF.

Input Amplifier

- Amplifier gain: 40dB in 5dB steps. <0.2dB gain error
- Additional gain: 0-5dB with an accuracy and resolution of ±0.1dB for calibration purposes
- Measurement range: 0.3μV-7V RMS (±11V peak). Corresponds to SPL values from –10dB to +137dB (140dB peak) with a mic. sensitivity of 50mV/Pa

- High pass filters: Selectable 1st order network with –3dB frequency at 0.03 Hz or 3rd order Butterworth filter at 16Hz (-3dB).

Self-Noise Levels

- Line input, spectral weighting networks; 90dB FSD. A: 10dB, C: 35dB, Flat (HP filter on): 37dB
- Mic. input, spectral weighting networks; 90dB FSD. A: 13dB, C: 16dB, Flat (HP filter on): 19dB
- Line & Mic. input, spectral weighting networks; 120dB FSD. A: 32dB, C: 35dB, Flat (HP filter on): 37dB
- High dynamic mode; A: 14dB, C: 17dB, Flat (HP filter on): 20dB
- Line corresponds to the self-noise measured with short circuited microphone signal input connector while Mic. corresponds to the self-noise measured with preamplifier Nor-1201 and an 18pF microphone equivalent Nor-1448-18pF.

Analogue Outputs

- AC outputs (two): 2.5mm mono mini-jack sockets. The output is generated by the DSP. One channel is normally used for AC output, the other channel is normally used for playback of the recorded signal or for voice notes. Optionally it may also be used for generator output
- Output level: ±10V peak,1.0Vrms corresponds to full scale deflection on display. Outputs are short circuit proof to ground and output current is in excess of 10mA
- Output impedance: Max: 10ohm
- Frequency range (AC output): 1-20000Hz±0.5dB.

Analogue to Digital Converter

- Converter type: Sigma delta with 64× oversampling
- Sampling rate: 48kHz

- Passband ripple: <0.1dB
- Stopband attenuation: >75dB above 1.3×cut-off frequency
- Digital filters: 6-pole IIR filters for octave and third-octave bands. The third-octave centre frequencies are set with the factor 10n/3
- Frequency range: 0.125Hz-16kHz for octave bands (centre frequencies). 0.1Hz-20kHz for third-octavebands (centre frequencies)
- Filter response: The octave and third-octave filters meet the re-quirements of IEC61260 class 1, ANSIS1.11-1986 Type 1D order III and IEC 225
- Spectral weighting networks: A, C and Flat. The Flat spectral weighting network response has a 1st order digital HP filter with fc (-1dB) selectable as 0.1, 1.0, 6.3 or 20Hz.

Larson Davis Model 831 Specification Sheet

Specifications

Standards Met by Model 831
The Model 831 meets the specifications of the following standards:
Sound Level Meter Standards
IEC61672-1 Ed. 1.0 (2002-05) Class 1, Group X
IEC60651 Ed 1.2 (2001) plus Amendment 1 (1993-02) and Amendment 2 (2000-10) Type 1, Group X
IEC60804 (2000-10) Type 1, Group X
ANSI S1.4-1983 (R 2006) plus Amendment S1.4A-1985 (R 2006) Type 1
ANSI S1.43-1997 (R 2007), Type 1
Octave Filter Standards (Option 831- OB3)
IEC61260 Ed. 1.0 (1995-08) plus Amendment 1 (2001-09), 1/1 and 1/3-octave Bands, Class 1, Group X, all filters
ANSI S1.11-2004 Class 1
Personal Noise Dosimeter Standards (Option 831-IH)
IEC61252 Ed. 1.1 (2002-03) Type 1
ANSI S1.25-1991 Class 1
Safety Requirements for Electrical Equipment for Measurement, Control Laboratory Use
IEC61010-1 Ed. 2.0 (2001-02)
EMC Immunity and Emission
89/336/EEC The Electromagnetic Compatibility Directive and its amending directives
EN 50081-1 (1992) - Electromagnetic compatibility - Generic emission standard Part 1. Residential, commercial, and light industry.
EN 50082-2 (1995) - Electromagnetic compatibility - Generic immunity standard Part 2. Industrial environment.

Model 831 General Features and Characteristics
Class 1 Precision Integrating Sound Level Meter with real-time 1/1 and 1/3 Octave Filters.
Non-Volatile Memory
High contrast 1/8th VGA LCD display with white LED backlight; sunlight readable
Icon-driven graphic user interface
Soft rubber backlit keys
Large dynamic range
Time weightings: Slow, Fast, Impulse, Integration and Peak simultaneously
Frequency weightings: A, C, Z simultaneously
1/1 and 1/3 octave frequency analysis available
Voice message annotation and sound recording
Ln statistics (L0.01 through L99.9 available)
SLM Utility software available for setup, control and high speed data download with export to MS Excel
Multi-tasking processor allows measuring while viewing data or transferring data
Data Secure Feature saves data to permanent memory every minute
AC/DC outputs to recorder
Long battery life; > 16 hours continuous measurement
Multiple Language Support: English, German, Italian, Spanish, Portuguese, Swedish, French
Field-upgradable firmware: keeps instrument current with the latest measurement features
Two-year limited warranty

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Sound Level Meter Specifications	
Averaging (Integration method)	Linear or Exponential
RMS Time weighting	Slow, Fast or Impulse
Frequency Weightings	A, C or Z
Peak detector Frequency weighting	A, C or Z
Reference range	0 dB or 20dB
Exchange rates	3, 4, 5, or 6 dB with optional 831-IH
Sample rate	51,200 Hz
Peak rise time	30 μs

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Physical Characteristics		
Length with microphone and preamplifier	11.35 in	29,0 cm
Length, instrument body only	8.8 in	22,4 cm
Width	2.8 in	7,10 cm
Depth	1.6 in	4,10 cm
Weight with batteries, no preamplifer or microphone	13.6 oz	390 g
Weight with batteries, preamplifer and microphone	1.2 lb	550 g

General Specifications	Back To Top
Reference level	114.0 dB SPL
Reference level range	Single large range for SLM Normal for OBA option
Reference frequency	1000 Hz
Reference direction	0° is perpendicular to the microphone diaphragm
Temperature ≤ ± 0.5 dB error between	≤ ± 0.5 dB error between -10° C and 50°C
Storage temperature	-20°C to 70°C
Humidity	≤ ± 0.5 dB error from 30% and 90% relative humidity at 40°C
Equivalent microphone impedance	12 pF for Larson Davis 1/2" microphone
Range level error (OBA option)	≤ ± 0.1 dB relative to the reference range
Digital Display Update Rate	Four times per second (0.25 sec between updates). First display indication is available 0.25 seconds after initiation of a measurement
Effect of an extension cable	None (up to 300 feet or 100 m with EXCxxx cable)
Electrostatic Discharges	The instrument is not adversely affected by electrostatic discharges
Extended weather options	-40 °C to +70 °C operation with CER-831-E

Resolution Specifications	
Levels	0.1 dB
Dose	0.1%
Elapsed time	0.1 second
Real time clock	1 second
Calendar	01 Jan 2008 - 31 Dec 2038
Integration Time	Back To Top
Time averaged Levels and Sound Exposure Levels (s)	
Minimum	0.1 second
Maximum with daily autostore enabled	Unlimited
Maximum with daily autostore disabled	> 23 days with error > 0.5 dB
Dosimeter Metrics: TWA, Dose (s)	
Minimum	0.1 second
Maximum	Unlimited
Ln Statistics	
Number of selectable parameters	6 in xx.xx% format, visible on Model 831
Storage of complete table	0.01% steps
Spectral Statistics	Requires enabling octave analysis (831-OB3) and Measurement History (831-ELA)
Markers	
Number of markers	10
Prenamed markers	5, Truck, Automobile, Motorcycle, Aircraft, Exclude
Link Marker to automatic Sound Recording	Yes, requires to enable Sound Recording (831-SR)
Back Erase	Back To Top
Number of markers	0, 5 or 10 seconds
Supported modes	Manual

Measurement Control Modes	
Available modes	Manual stop, Timed Stop, Stop when stable, Continuous, Single Block Timer, Daily Block Timer
Available modes with measurement history	Continuous, Single Block Timer, Daily Block Timer
Timed Stop	Time in hh:mm:ss
Stop When Stable	Delta level in xx.x dB and time in hh:mm:ss
Continuous with daily autostore	1, 2, 4, 6, 12 or 24 files per day, automated file numbering "yymmddnn.LD0"
Continuous restart on power failure	Automatic if powered by 12VDC
Single Block Timer	Start date and time to End data and time
Daily Block Timer	Up to 3 blocks with each start and end date, blocks can cross midnight line
Clock Stability	
	< 1 sec in 24 hours at 24 C
	< 1 sec in 24 hours at 24 C
Digital Voice Annotation	Back To Top
Annotate recordings	Use headset (ACC003) or measurement microphone
Recording frequency	8 kHz
Listening options	On Model 831 or using processing software for WAV files
AC/DC Output	
Jack (Fem)	2.5 mm, see CBL139 cable
AC Output Voltage Range	± 2.3Vpeak maximum output, 0.5mV to 1.6Vrms sine
AC Output Recommended Load	Headset with ≥ 16 W speaker impedance
DC Output Voltage Range	0 V for 0dB, 1 V for 100dB
DC Output Freq & Time Weighting	Follows SLM Detector: F,S, or I and A, C, or Z
Tee-off preamplifier signal Alternative	Use ADP015 and EXC006

Power Supply	
Batteries	4-AA (LR6) NiMH, Lithium or Alkaline cells (supplied with 2500 mAh NiMH)
External Power (5V from USB)	USB Mini-B connector to * USB interface from computer * PSA029 AC to DC Power Adapter * USB Hub * PSA031 12VDC to USB Adaptor
External Power	Power through I/O connector: 10 to 15.5 Vdc. Use cable
	CBL140, CBL154 or Model 831-INT Interface Unit
Operating time on E-Lithium	> 24 hours with power save options, 1 sec Leq logging
Power consumption with PRM831	1.1 W (backlight off, running)

Memory Retention	Back To Top
Data Memory	Non-volatile flash memory every minute update
Real-time clock	≥ 10 minutes

Broadband Noise Levels				
Self-Generated Electrical Noise				
Weighting	0 dB Gain		20 dB Gain	
	typical (dB)	max (dB)	typical (dB)	max (dB)
A	13	15	6	10
C	15	22	12	16
Z	22	25	19	26
Self-Generated Total Noise				
Weighting	0 dB Gain		20 dB Gain	
	typical (dB)	max (dB)	typical (dB)	max (dB)
A	18	19	17	17
C	18	23	17	19
Z	23	26	21	26
Combination of the electronic noise and the thermal noise of the 377B02 microphone at 20 °C measured in a sealed cavity and vibration isolated with an averaging time of 60 seconds. Electronic noise of the instrument with an ADP090 (12 pF) in place of the microphone highest anticipated self-generated noise.				

Appendix D: Site Description and Images

Each site entry contains a brief description of the location of the site, as well as several images of the location and, when possible, device setup.

SJA2_02_1036 (Parque Central)

The site was across a highway and right on the steps of the Natatorium, which is a local outdoor aquatic center. The site consisted of the Natatorium and a highway across the street.

Figure 10: Parque Central, Highway View

Figure 11: Parque Central, Park View

SJA2_05_1100 (Universidad de Sagrado Corazón)

This site is across from the Universidad de Sagrado Corazón. The area has a lot of small businesses, so there is a lot of foot traffic, as well as vehicular traffic. There are also a number of residential dwellings in the area.

Figure 12: Universidad de Sagrado Corazón, Front Gate

Figure 13: Universidad de Sagrado Corazón, Site Traffic

SJA3_03_1228 (Calle Cuba)

This is a residential area. The houses in this area are old and the site is not as tranquil as Calle 19 or República de Colombia. There was significantly more foot traffic than in other residential areas, and we could hear more voices as well coming from the houses.

Figure 14: Calle Cuba, Side Street

Figure 15: Calle Cuba, Road View

SJA4_06_0417 (Calle 19)

This is a quiet residential area with several traditional Puerto Rican-styled homes. It is a tranquil neighborhood filled with families and the elderly.

Figure 16: Calle 19, Device Placement

Figure 17: Calle 19, Road View

SJA4_10_0714 (Centro Médico)

Centro Médico is an urban area with a train station, residences, a psychiatric rehabilitation center and a medical school.

Figure 18: Centro Médico, Side Street

Figure 19: Centro Médico, Road View

SJA5_08_0957 (República de Colombia)

This is a residential area nearly identical to Calle 19 that is very close to Barbosa.

Figure 20: República de Colombia, Device Placement

Figure 21: República de Colombia, Road View

SJA5_09_1134 (Barbosa)

This area has a fairly complex road network. There are no residences and there are a few small businesses.

Figure 22: Barbosa, Device Placement

Figure 23: Barbosa, Road View

SJA6_07_1872 (Colegio Mizpa)

This site is a theological university that is across from a well-trafficked road. Aside from the roadway, the site is very quiet. There are no businesses in this area.

Figure 24: Colegio Mizpa, Device Placement

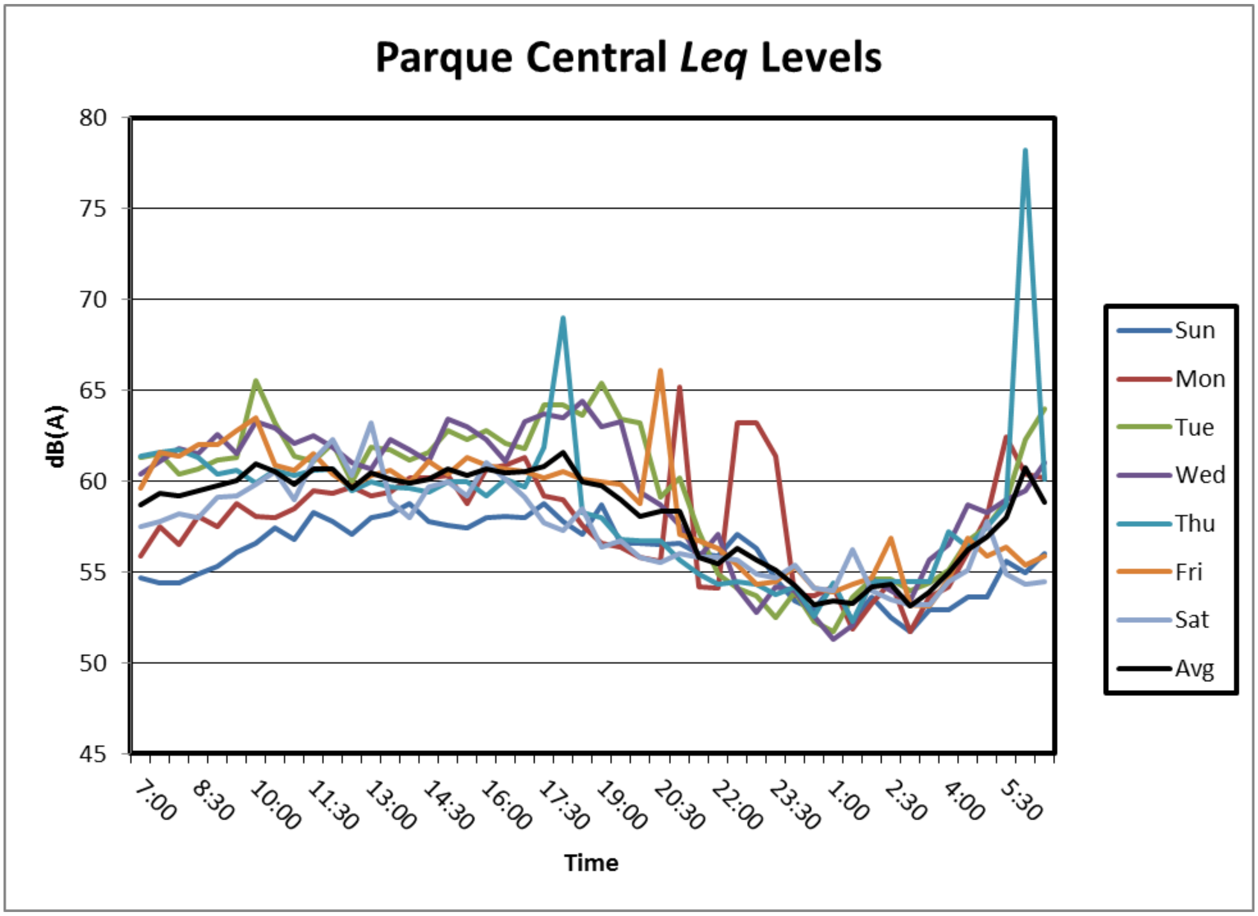
Figure 25: Colegio Mizpa, Waterproof Casing and Theft Deterrence

Appendix E: L_{90}, L_{eq}, L_{10} Graphs and *CV* Tables

This Appendix contains graphs of all collected and available temporal variability sound level data. In certain instances, only L_{eq} values were retrievable from the device. In other situations, data were corrupted, and no graphs could be produced. All meters were set to record for seven days; however, due to loss of power, overheating, or other technical issues, the devices occasionally stopped recording data prematurely. In these instances, only five or six days of information are graphed.

Additionally, each entry includes a *CV* value table to accompany the L_{eq} graphs. A *CV* value, or a Coefficient of Variation, is an indication of the amount of temporal variability of noise. The greater the *CV* value, the greater the temporal variability in relation to the rest of the dataset. It is calculated as the standard deviation of a dataset divided by the average of that dataset, multiplied by 100.

SJA2_02_1036 (Parque Central)



Graph 4: Parque Central, L_{eq}

Overall, Parque Central was constant throughout the week. The decibel levels stayed between 55 and 60 decibels. As the site was located on the edge of the park near a highway, noise from traveling cars and trucks was constant throughout the day. As one might expect, it drops off as less cars and trucks travel the roads from 10:00pm through 5:00am before picking back up for early-morning overnight shipments. One might expect to see a spike at 6:30pm due to the coquís calling; however, the noise from the nearby highway masks any potential rise from the coquís. Sunday was the quietest day of the week, probably due to fewer vehicles on the highway. Furthermore, the Natatorium (covered swimming pool stadium) next door could have been the cause of some of the spikes.

Certain spikes, such as Monday and Friday around 8:30pm-9:00pm, could have been caused by swimming competitions, regular free swim hours, or early morning maintenance. The source of the spike at 6:00am on Thursday cannot be determined, as the data were not retrieved and analyzed until after data gathering had stopped. Given the lack of repeatability in any other day, as well as the outlying nature of the spike, it appears to have been a single-time occurrence. A traffic accident would have had longer repercussions, as they take several hours to clean up. More likely, a person either spoke or shouted into the microphone after discovering it, or an animal of some kind rubbed against it. The rumble from the contact could have affected data collection in this manner.

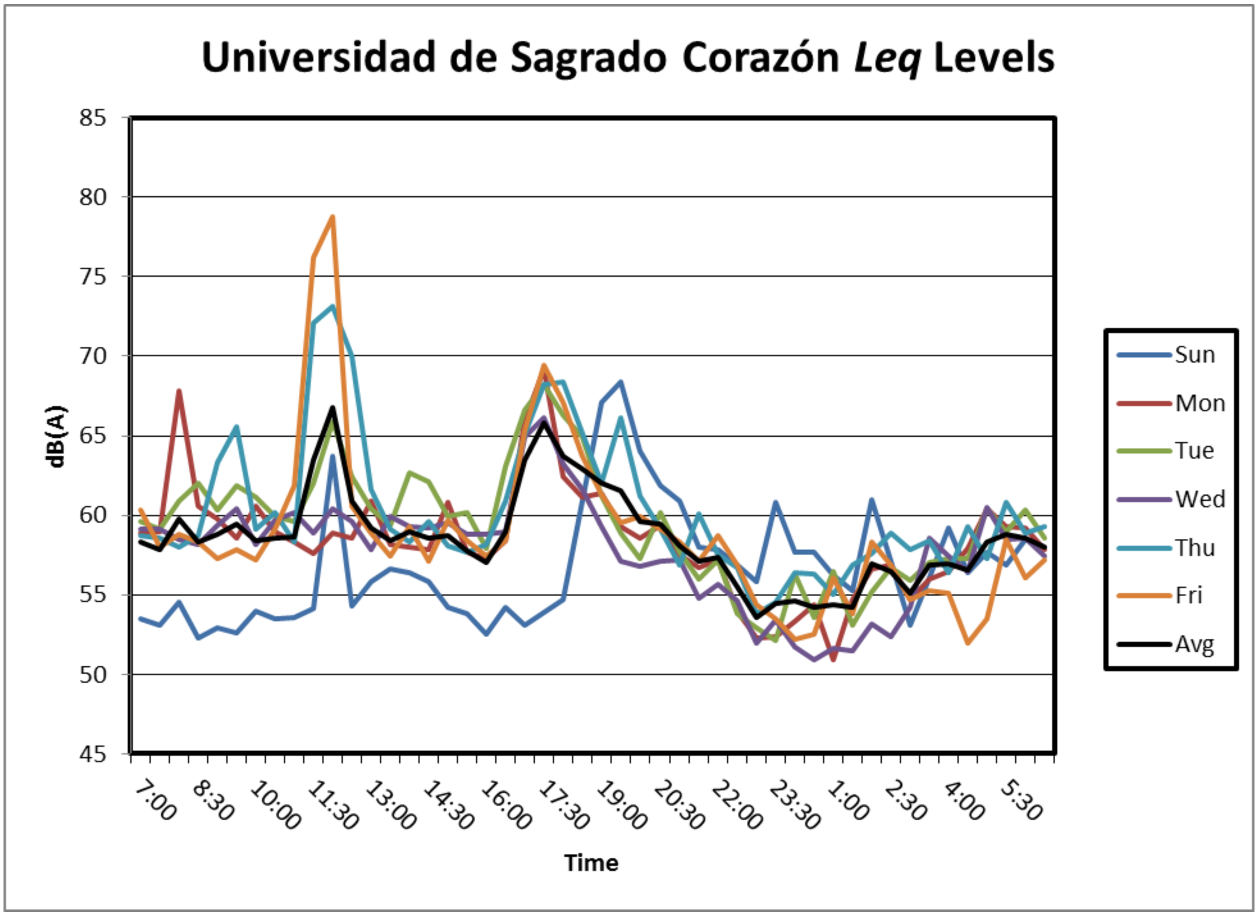
Looking at the coefficient of variation (*CV*) in Table 5, a quantifiable measure of the variation at each time on the graph, surprisingly few points of interest appear. The only *CV* of interest (calculated by dividing the standard deviation of a time set by the mean for the same time set and multiplying by 100), is 13.6, at 6:00am. However, this variability is affected by the Thursday spike. When the Thursday 6:00am data point is ignored, the *CV* reduces to 5.8, a much more reasonable number.

Time	**AVG**	**STD**	***CV***	**Time**	**AVG**	**STD**	***CV***	**Time**	**AVG**	**STD**	***CV***
7:00	58.7	2.7	4.6	**15:00**	60.6	1.9	3.2	**23:00**	55.6	3.5	6.3
7:30	59.4	2.8	4.8	**15:30**	60.3	2.0	3.3	**23:30**	55.1	2.9	5.2
8:00	59.2	2.9	4.9	**16:00**	60.7	1.7	2.7	**0:00**	54.3	0.8	1.4
8:30	59.5	2.6	4.4	**16:30**	60.4	1.2	2.0	**0:30**	53.2	0.8	1.4
9:00	59.7	2.6	4.4	**17:00**	60.5	1.8	2.9	**1:00**	53.4	1.3	2.5
9:30	60.0	2.2	3.7	**17:30**	60.8	2.5	4.1	**1:30**	53.2	1.6	3.0
10:00	61.0	3.2	5.3	**18:00**	61.6	4.2	6.8	**2:00**	54.2	0.6	1.0
10:30	60.5	2.2	3.6	**18:30**	59.9	2.9	4.9	**2:30**	54.4	1.3	2.5
11:00	59.8	1.8	3.1	**19:00**	59.7	3.4	5.6	**3:00**	53.1	1.1	2.0
11:30	60.7	1.4	2.3	**19:30**	59.0	3.2	5.4	**3:30**	53.9	1.0	1.9
12:00	60.6	1.7	2.7	**20:00**	58.0	2.7	4.6	**4:00**	55.0	1.4	2.6
12:30	59.6	1.2	2.0	**20:30**	58.3	3.7	6.4	**4:30**	56.2	1.6	2.8
13:00	60.5	1.7	2.8	**21:00**	58.3	3.4	5.8	**5:00**	57.0	1.7	2.9
13:30	60.1	1.5	2.5	**21:30**	55.8	1.0	1.8	**5:30**	58.0	2.6	4.4

14:00	59.9	1.3	2.1	**22:00**	55.5	1.1	2.0	**6:00**	60.7	8.3	13.6
14:30	60.1	1.3	2.2	**22:30**	56.3	3.2	5.7	**6:30**	58.8	3.4	5.8

Table 5: Parque Central *CV* values

SJA2_05_1100 (Universidad de Sagrado Corazón)



Graph 5: Universidad de Sagrado Corazón, L_{eq}

Graph 5 shows the 50th percentile data for Universidad de Sagrado Corazón. The seven lines plotted each represent a full day's worth of data (the seventh line is the average of the L_{eq} values of all six days at each data point). For this graph, one day of data is missing because of equipment failure.

Universidad de Sagrado Corazón was loud at certain key times throughout the day. The graph shows that Sunday has the lowest dB levels. It also shows Friday and Thursday as having high noise levels around 12:00 pm. Since this site is a university, these peaks could be due to students who are leaving class and going to lunch. At around 5:00 pm every day, there was a peak of noise, due to rush hour traffic. From the hours of 10:00 pm to 6:00 am, we observed the lowest dB levels in this area. During these hours of the day most people are asleep, resulting in less activity and noise. From our characterization of noise sources in the area, we can infer that the causes of these spikes of noise are most likely traffic-related. Students and professors leaving and entering the University's parking lot, along with an occasional airplane flying overhead, caused most of the noise levels recorded.

Table 6 provides quantified data about the temporal variability of Universidad de Sagrado Corazón. The *CV* value, or a Coefficient of Variation, is an indication of the amount of temporal variability of noise. The greater the *CV* value, the greater the temporal variability in relation to the rest of the dataset. For example, the *CV* value of 13.8 and 11.5 at 11:30am and 12:00pm indicates a great deal of temporal variability between the days of the week's noise level. *CV* values of 2.4 and 1.4 at 6:00am and 6:30am are indicative of little variance of noise levels among the days of the week. This quantified data shows trends of how the site behaves over a week, with relatively low *CV* values presenting evidence that the site's dB levels are consistent. High *CV* levels denote a chaotic time of the week, a period of time where the dB level varies greatly per day.

Time	**AVG**	**STD**	***CV***	**Time**	**AVG**	**STD**	***CV***	**Time**	**AVG**	**STD**	***CV***
7:00	58.4	2.4	4.2	**15:00**	58.7	2.4	4	**23:00**	53.5	1.4	2.7
7:30	57.8	2.3	4.1	**15:30**	57.8	2.2	3.7	**23:30**	54.5	3.2	5.9
8:00	59.8	4.5	7.5	**16:00**	57.0	2.3	4	**0:00**	54.6	2.5	4.6
8:30	58.4	3.3	5.7	**16:30**	59.0	3.0	5	**0:30**	54.2	2.5	4.6
9:00	58.8	3.5	5.9	**17:00**	63.5	5.1	8.1	**1:00**	54.4	2.5	4.6
9:30	59.5	4.4	7.3	**17:30**	65.8	6.0	9.1	**1:30**	54.2	1.9	3.4
10:00	58.4	2.6	4.4	**18:00**	63.7	5.0	7.8	**2:00**	57.0	2.7	4.7
10:30	58.6	2.5	4.3	**18:30**	62.9	1.9	3.1	**2:30**	56.5	2.2	3.8
11:00	58.7	2.8	4.8	**19:00**	62.1	2.6	4.3	**3:00**	55.1	1.6	2.9
11:30	63.5	8.7	13.8	**19:30**	61.6	4.6	7.4	**3:30**	56.9	1.4	2.4
12:00	66.8	7.7	11.5	**20:00**	59.6	2.7	4.5	**4:00**	57.0	1.4	2.4
12:30	60.9	5.2	8.6	**20:30**	59.5	1.6	2.6	**4:30**	56.6	2.5	4.4

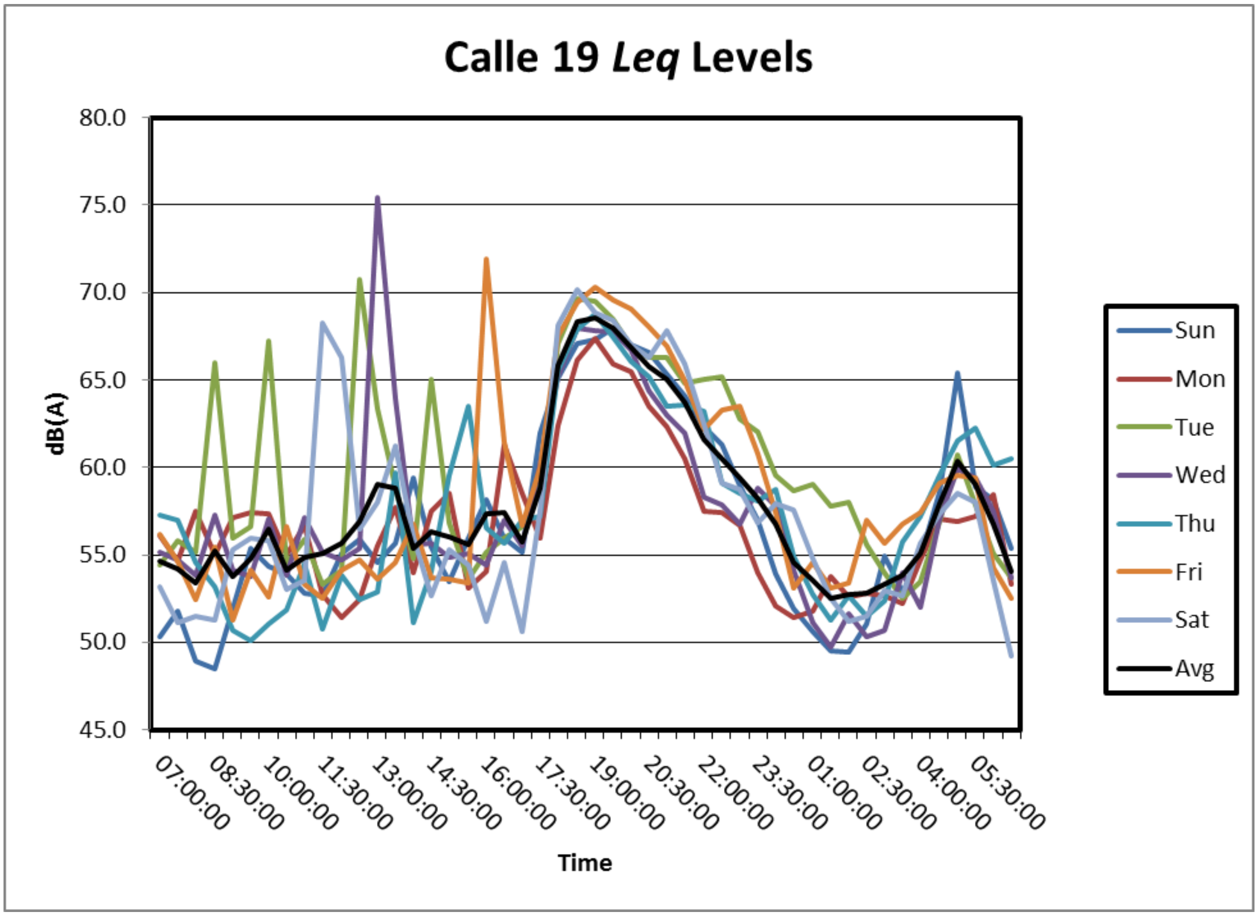
13:00	59.2	2.2	3.7	**21:00**	58.1	1.5	2.5	**5:00**	58.3	2.8	4.7
13:30	58.4	1.3	2.2	**21:30**	57.1	1.8	3.2	**5:30**	58.8	1.3	2.2
14:00	59.0	2.1	3.6	**22:00**	57.4	1.0	1.7	**6:00**	58.6	1.4	2.4
14:30	58.6	2.2	3.8	**22:30**	55.5	1.5	2.7	**6:30**	58.0	0.8	1.4

Table 6: Universidad de Sagrado Corazón *CV* values

SJA3_03_1228 (Calle Cuba)

Unfortunately, the 7 week data collected at Calle Cuba were corrupted and were not able to be retrieved. Due to time constraints, we were not able to return to the site and start a new seven-day data collection. We do have characterization data available in Appendix F. Additionally, we have site description and images in Appendix D. Calle Cuba was a residential area and had an analagous sound profile to Calle 19.

SJA4_06_0417 (Calle 19)



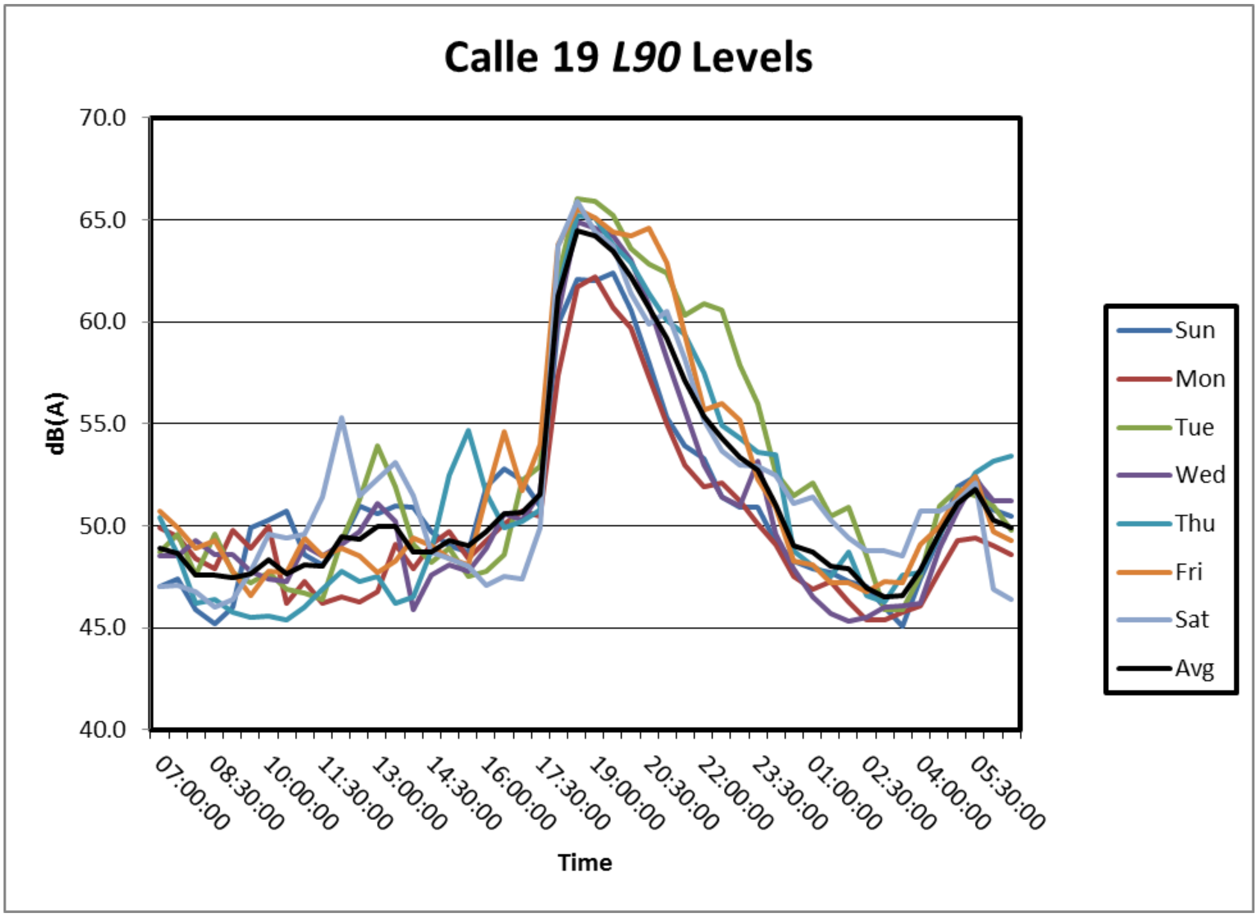
Graph 6: Calle 19, L_{eq}

Calle 19, being a residential area, did not experience a significant amount of temporal variability based on the *CV* numbers in Table 7. Observing the *CV* numbers, it is easy to see that for the most part the numbers stay in the range of 1.8 – 6.8 and only occasionally spiking up to a value of 12 or higher. The drop shows that there is some temporal variability, which is to be expected; however, this amount is not very significant. The spikes in the *CV* numbers can visually be seen by the two spikes of interest in Graph 6, which can be seen at 5:00 am and again at 6:00 pm - 6:30 pm. The spike at 5:00 am could possibly be explained by animals, such as roosters, dogs, or birds, in the neighborhood waking up and creating environmental noise. The 6:00 pm spike can possibly be explained by several reasons like locals arriving home from work, locals doing yard work outside, or local families having dinner.

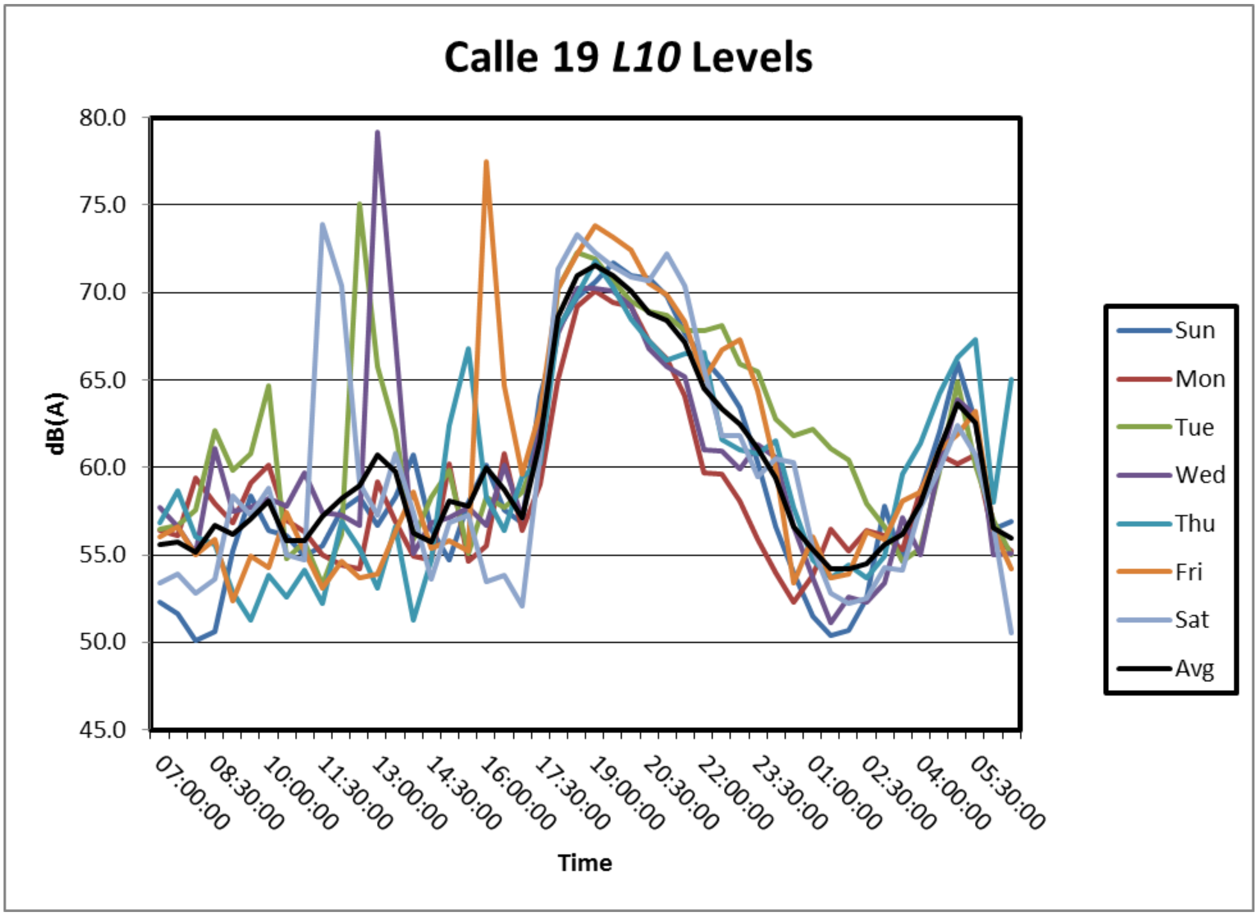
From an overall perspective, Calle 19 really only sees temporal variability early on in the day due to it being a residential area which is relatively quiet during the day other than the occasional car passing by. It then follows a more regular trend throughout the day, only spiking at the times explained above. In conclusion, Calle 19 is a relatively quiet site, and shows tendencies that are characteristic of residential life with no real odd phenomena present in its sound profile.

Time	**AVG**	**STD**	***CV***	**Time**	**AVG**	**STD**	***CV***	**Time**	**AVG**	**STD**	***CV***
7:00	54.7	2.3	4.2	**15:00**	56.0	2.4	4.2	**23:00**	59.4	2.7	4.6
7:30	54.2	2.1	3.9	**15:30**	55.6	3.6	6.5	**23:30**	58.2	2.7	4.6
8:00	53.4	2.8	5.2	**16:00**	57.3	6.8	11.8	**0:00**	56.8	2.7	4.8
8:30	55.2	5.6	10.1	**16:30**	57.4	2.8	4.9	**0:30**	54.5	2.7	5.0
9:00	53.8	2.5	4.7	**17:00**	55.7	2.5	4.5	**1:00**	53.5	2.9	5.4
9:30	54.8	2.4	4.5	**17:30**	58.8	2.1	3.5	**1:30**	52.5	2.8	5.4
10:00	56.5	5.3	9.3	**18:00**	65.8	1.9	2.9	**2:00**	52.7	2.7	5.0
10:30	54.1	1.5	2.8	**18:30**	68.3	1.5	2.1	**2:30**	52.8	2.5	4.8
11:00	54.8	1.7	3.2	**19:00**	68.6	1.1	1.6	**3:00**	53.3	1.7	3.2
11:30	55.0	6.0	10.8	**19:30**	67.9	1.1	1.7	**3:30**	53.8	1.8	3.3
12:00	55.7	4.8	8.7	**20:00**	66.9	1.1	1.7	**4:00**	55.0	1.9	3.5
12:30	56.9	6.3	11.1	**20:30**	65.8	1.5	2.3	**4:30**	57.9	1.1	1.9
13:00	59.1	8.0	13.6	**21:00**	65.0	2.1	3.3	**5:00**	60.4	2.7	4.4
13:30	58.8	3.2	5.5	**21:30**	63.7	1.9	2.9	**5:30**	59.0	1.7	2.8

Table 7: Calle 19 *CV* values

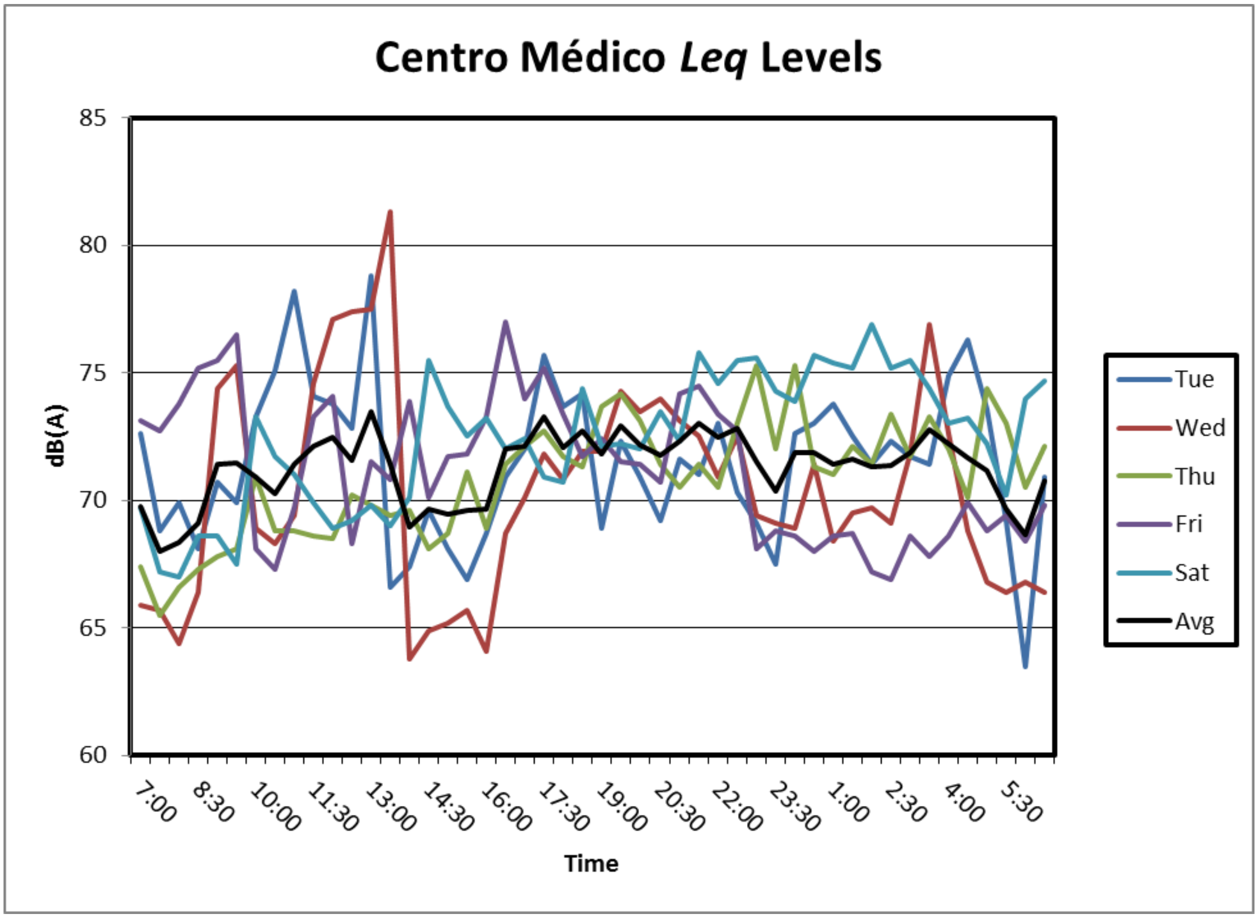


Graph 7: Calle 19, L_{90}



Graph 8: Calle 19, L_{10}

SJA4_10_0714 (Centro Médico)



Graph 9: Centro Médico, L_{eq}

Centro Médico showed several very interesting trends, seen in Graph 9. Of the five days of data collected, no discernable pattern is visible from the days. However, the rise and fall of the decibel level over the day and night seen in other sites is not apparent in this data, suggesting an entirely different noise pattern. The mean decibel level at the site was 71.3 dB, extraordinarily high. The maximum *CV* in Table 8 was 8.0, indicating little temporal variability. The tendency is “organized chaos” - that is, the noise is not constant enough to repeat day to day, but is constant enough to maintain an above-regulation decibel level, even from 12:00am-5:00am. Based on proximity, a likely source of noise is the train. The periodic train passing through routinely exposes residents to high noise levels. Additionally, the nearby Centro Médico hospital, replete with ambulances and police vehicles blaring their sirens throughout the night, could be another source of noise.

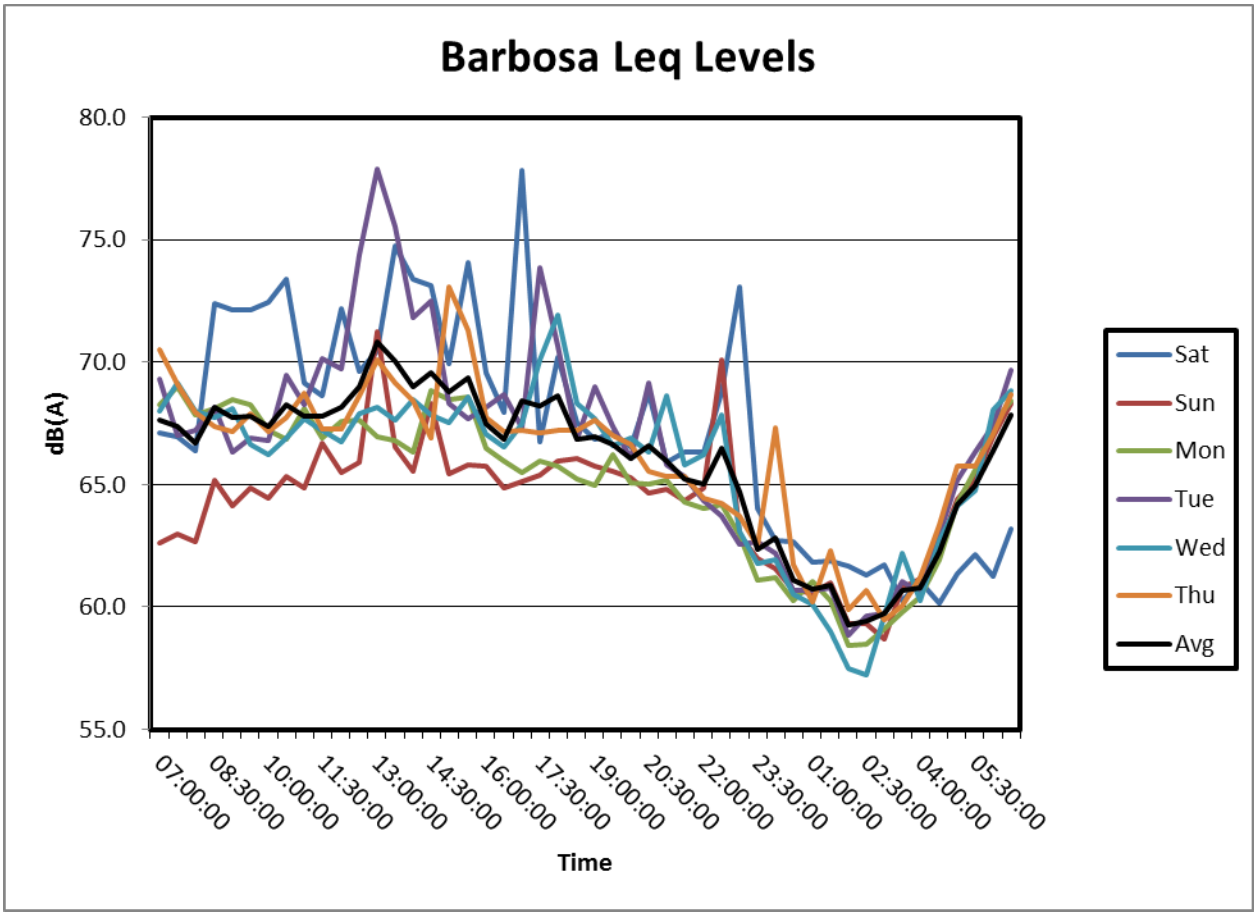
Time	AVG	STD	*CV*	Time	AVG	STD	*CV*	Time	AVG	STD	*CV*
7:00	69.7	3.2	4.5	**15:00**	69.5	3.3	4.8	**23:00**	71.5	3.6	5.1
7:30	68.0	3.0	4.3	**15:30**	69.6	3.1	4.4	**23:30**	70.3	2.8	3.9
8:00	68.3	3.6	5.3	**16:00**	69.6	3.8	5.5	**0:00**	71.9	3.0	4.2
8:30	69.1	3.5	5.1	**16:30**	72.0	3.1	4.3	**0:30**	71.9	2.8	3.9
9:00	71.4	3.4	4.8	**17:00**	72.1	1.4	1.9	**1:00**	71.4	3.1	4.4
9:30	71.5	4.2	5.8	**17:30**	73.3	2.1	2.9	**1:30**	71.6	2.6	3.6
10:00	70.9	2.4	3.4	**18:00**	72.1	1.4	2.0	**2:00**	71.3	3.6	5.0
10:30	70.2	3.2	4.5	**18:30**	72.7	1.5	2.0	**2:30**	71.4	3.3	4.7
11:00	71.4	3.9	5.4	**19:00**	71.8	1.8	2.5	**3:00**	71.9	2.4	3.4
11:30	72.1	2.7	3.7	**19:30**	72.9	1.3	1.7	**3:30**	72.8	3.4	4.7
12:00	72.5	3.7	5.1	**20:00**	72.2	1.1	1.5	**4:00**	72.2	2.3	3.2
12:30	71.6	3.7	5.1	**20:30**	71.8	2.0	2.8	**4:30**	71.7	3.1	4.3
13:00	73.5	4.3	5.9	**21:00**	72.3	1.4	2.0	**5:00**	71.2	3.2	4.6
13:30	71.4	5.7	8.0	**21:30**	73.0	2.1	2.8	**5:30**	69.6	2.4	3.4
14:00	69.0	3.7	5.4	**22:00**	72.5	1.7	2.4	**6:00**	68.6	3.9	5.7
14:30	69.6	3.9	5.5	**22:30**	72.8	1.8	2.5	**6:30**	70.8	3.1	4.3

Table 8: Centro Médico *CV* values

SJA5_08_0957 (República de Colombia)

Unfortunately, the 7 week data collected at República de Colombia were corrupted and were not able to be retrieved. Due to time constraints, we were not able to return to the site and start a new seven-day data collection. We do have characterization data available in Appendix F. Additionally, we have site description and images in Appendix D. República de Colombia was a residential area and had an analagous sound profile to Calle 19.

SJA5_09_1134 (Barbosa)

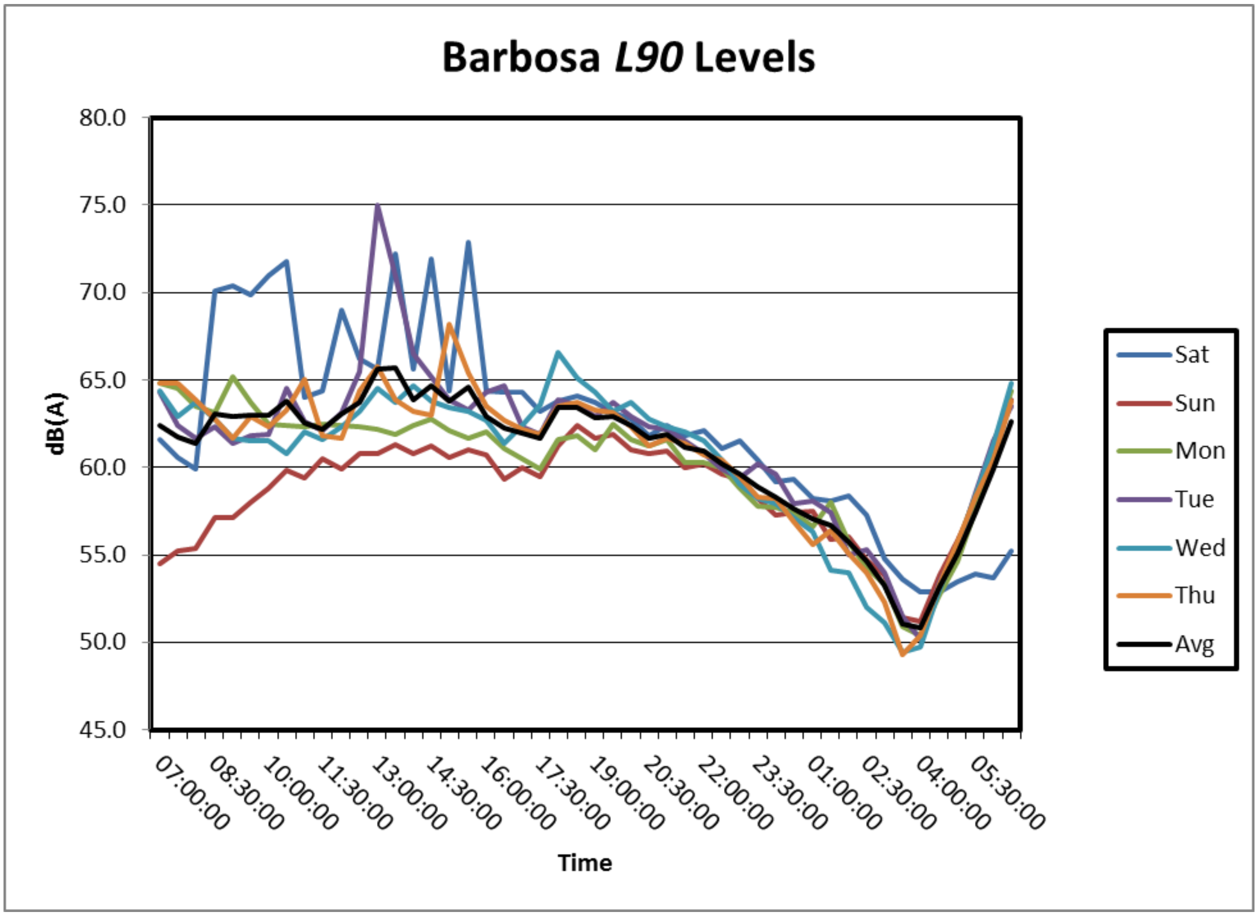


Graph 10: Barbosa, L_{eq}

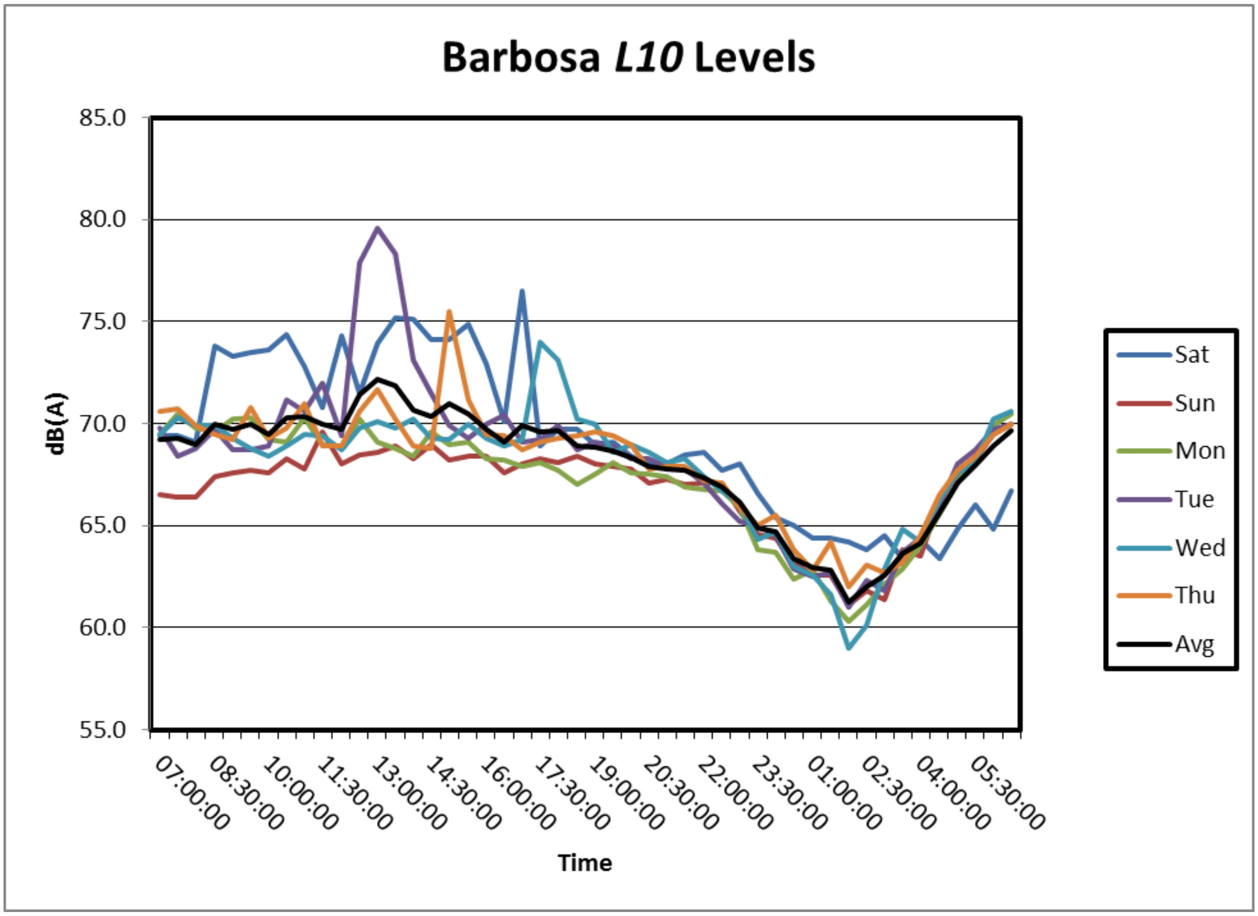
In the morning during all of the days of the week, the average dB level is around 67 dB. There is temporal variability during the day, shown in multiple large peaks on Graph 10. These peaks could be due to large trucks, shuttles, or cars playing music driving through the intersection. The average line shows a higher temporal variability during the late morning and early afternoon hours. As seen in Table 9, the *CV* varies, having points where the *CV* is 3.5, then decreases to around 2.0 and then increases to about 5.8. Then around 6:30 pm, the average dB level begins to decrease. Since the noise at Barbosa is mostly due to traffic, the decrease after 6:30 could indicate people leaving work and going home for the night, eliminating the number of cars on the road. The lowest dB levels occur at 2:00 am. At this point is when the *CV* remains more constant. There is a point where the *CV* is 0.7, which indicates a point where the dB reaches the same level at around the same time every day of the week. After about 4:00 am, the dB rises, which could be due to people leaving for work. Saturday is an exception to this trend. Though it does decrease from the late hours of the night into the early hours of the morning, it has a higher dB at 2:00 am than the other days of the week. This could be due to the increased social activity on Saturdays. But then later into the morning, the dB remains lower on Saturday, most likely due to the fact that there will be fewer people going to work on a Saturday morning, resulting in fewer cars going through the intersection. The dB level at Barbosa is generally very high and mostly ranges between 65 and 75 dB.

Time	**AVG**	**STD**	***CV***	**Time**	**AVG**	**STD**	***CV***	**Time**	**AVG**	**STD**	***CV***
7:00	67.6	2.7	4.0	**15:00**	68.8	2.6	3.7	**23:00**	64.7	4.1	6.4
7:30	67.4	2.4	3.5	**15:30**	69.3	2.9	4.2	**23:30**	62.3	1.0	1.6
8:00	66.7	2.1	3.1	**16:00**	67.5	1.3	2.0	**0:00**	62.8	2.3	3.6
8:30	68.2	2.3	3.4	**16:30**	66.9	1.4	2.1	**0:30**	61.1	0.9	1.5
9:00	67.7	2.7	3.9	**17:00**	68.4	4.7	6.9	**1:00**	60.7	0.6	1.1
9:30	67.8	2.4	3.6	**17:30**	68.2	3.2	4.7	**1:30**	60.9	1.2	1.9
10:00	67.4	2.7	4.0	**18:00**	68.6	2.6	3.8	**2:00**	59.3	1.4	2.4
10:30	68.3	2.8	4.1	**18:30**	66.9	1.1	1.6	**2:30**	59.4	1.5	2.5
11:00	67.8	1.5	2.3	**19:00**	67.0	1.4	2.2	**3:00**	59.7	1.1	1.8
11:30	67.8	1.3	2.0	**19:30**	66.6	0.7	1.0	**3:30**	60.7	0.9	1.5
12:00	68.2	2.4	3.5	**20:00**	66.1	0.7	1.1	**4:00**	60.8	0.4	0.7
12:30	69.0	2.9	4.2	**20:30**	66.6	1.9	2.9	**4:30**	62.3	1.1	1.8
13:00	70.8	3.8	5.4	**21:00**	65.9	1.4	2.1	**5:00**	64.2	1.5	2.4
13:30	70.1	4.0	5.8	**21:30**	65.3	0.8	1.2	**5:30**	65.0	1.5	2.3
14:00	69.0	3.1	4.4	**22:00**	65.0	1.0	1.5	**6:00**	66.4	2.5	3.8
14:30	69.6	2.6	3.7	**22:30**	66.5	2.8	4.2	**6:30**	67.9	2.3	3.5

Table 9: Barbosa *CV* values

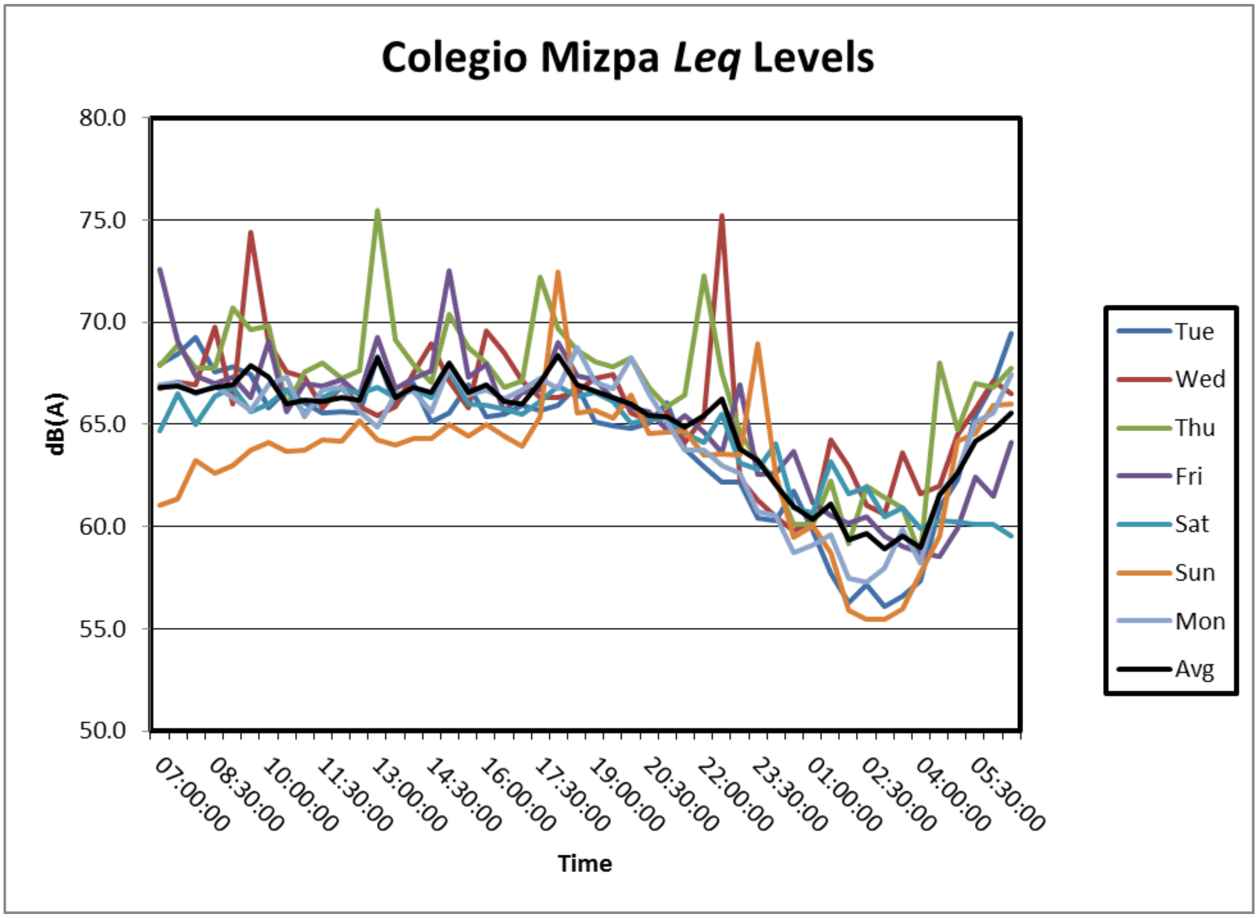


Graph 11: Barbosa, L_{90}



Graph 12: Barbosa, L_{10}

SJA6_07_1872 (Colegio Mizpa)

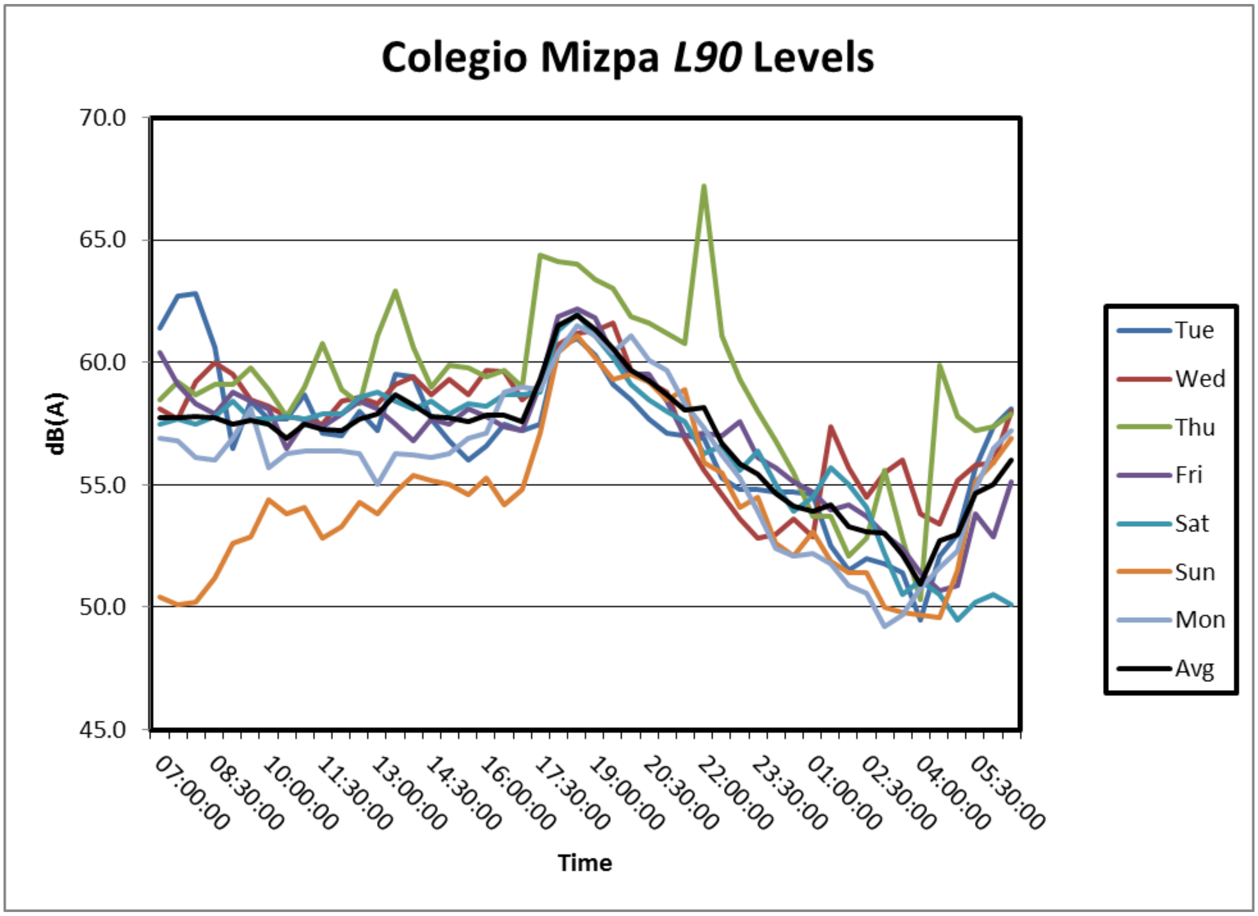


Graph 13: Colegio Mizpa, L_{eq}

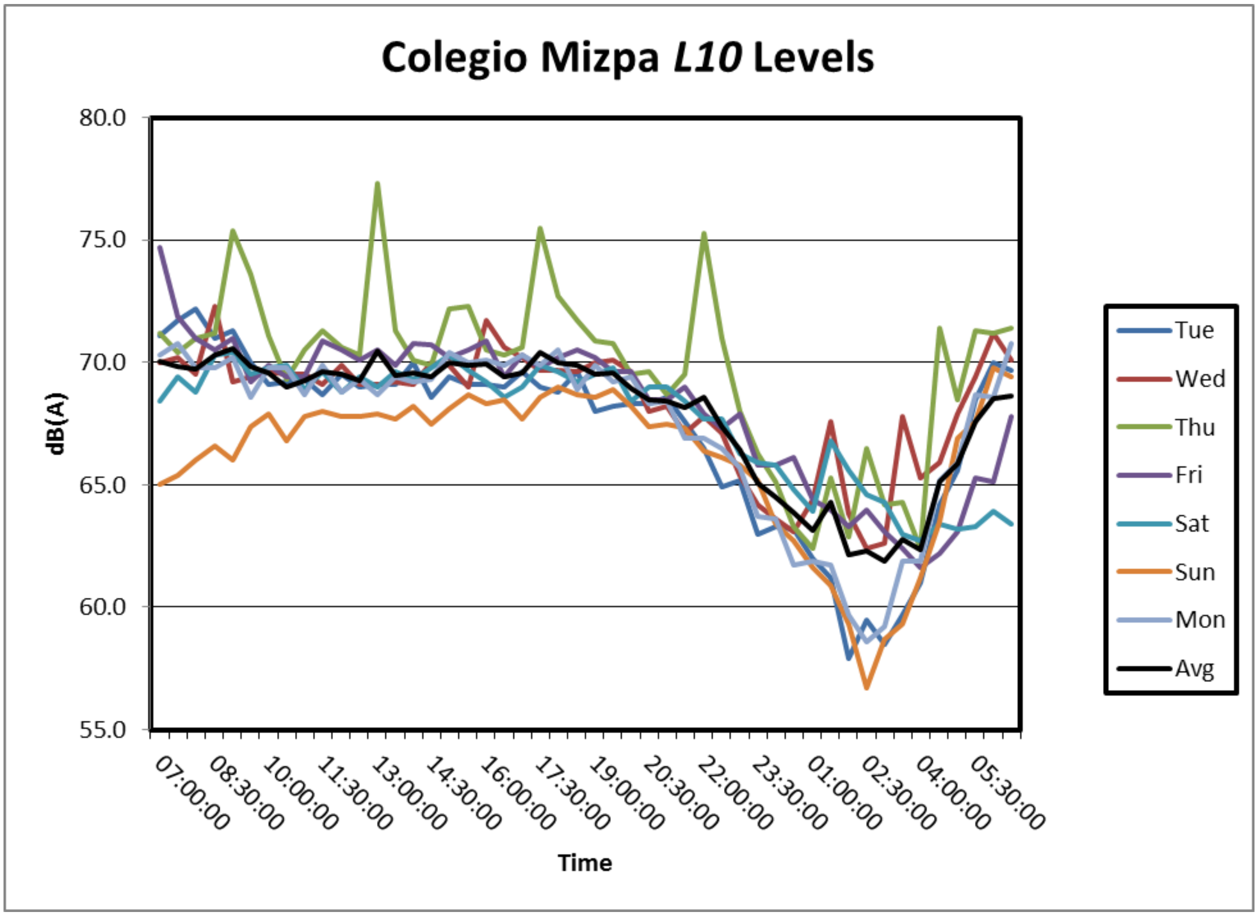
From Graph 13, one can see that the level of noise stays fairly constant until about 8:00 pm. After 8:00 pm, it gradually decreases until it reaches a minimum at around 2:00 am and then gradually increases again. From 7:00 am – 8:00 pm, the decibel levels are most likely due to traffic and the peaks on Wednesday, Thursday and Friday at 9:00 am – 10:00 am, 12:00 pm – 1:00 pm and 2:00 pm – 3:00 pm respectively are most likely due to classroom activities. The peak on Sunday from 5:00 pm – 6:30 pm could the sound from a religious ceremony. The late night peaks on Wednesday, Thursday and Sunday are most likely due to social gatherings. The rise in decibel level from 2:00 am – 6:00 am is most likely due to animals and the increase in traffic flow. From the *CV* values in Table 10, the greatest amount of temporal variability occurs in the morning and gradually decreases as the day progresses. According to Graph 13, Sunday is the quietest day, and the other days have similar decibel levels.

Time	AVG	STD	*CV*	Time	AVG	STD	*CV*	Time	AVG	STD	*CV*
7:00	66.8	3.8	5.7	**15:00**	68.0	2.9	4.3	**23:00**	63.8	1.8	2.8
7:30	66.9	2.9	4.3	**15:30**	66.5	1.5	2.3	**23:30**	63.2	3.0	4.7
8:00	66.6	2.1	3.2	**16:00**	67.0	1.8	2.7	**0:00**	62.0	1.4	2.3
8:30	66.8	2.4	3.6	**16:30**	66.1	1.4	2.1	**0:30**	61.0	1.6	2.6
9:00	66.9	2.5	3.7	**17:00**	66.0	1.2	1.8	**1:00**	60.4	0.5	0.8
9:30	67.9	3.7	5.4	**17:30**	67.1	2.6	3.9	**1:30**	61.1	2.6	4.3
10:00	67.3	2.3	3.4	**18:00**	68.4	2.5	3.7	**2:00**	59.3	2.8	4.7
10:30	66.0	1.3	2.0	**18:30**	66.9	1.0	1.5	**2:30**	59.7	2.7	4.5
11:00	66.2	1.4	2.1	**19:00**	66.7	1.1	1.6	**3:00**	58.9	2.5	4.2
11:30	66.1	1.3	2.0	**19:30**	66.3	1.1	1.7	**3:30**	59.5	2.9	4.9
12:00	66.3	1.2	1.8	**20:00**	66.0	1.3	2.0	**4:00**	59.0	1.6	2.7
12:30	66.2	0.9	1.4	**20:30**	65.4	0.8	1.2	**4:30**	61.6	3.4	5.5
13:00	68.3	4.0	5.9	**21:00**	65.4	0.6	0.9	**5:00**	62.6	2.2	3.5
13:30	66.3	1.7	2.6	**21:30**	64.8	1.0	1.5	**5:30**	64.2	2.5	3.9
14:00	66.8	1.3	1.9	**22:00**	65.5	3.4	5.2	**6:00**	64.7	3.1	4.8
14:30	66.6	1.7	2.6	**22:30**	66.3	4.8	7.2	**6:30**	65.6	3.5	5.3

Table 10: Colegio Mizpa *CV* values



Graph 14: Colegio Mizpa, L_{90}



Graph 15: Colegio Mizpa, L_{10}

Appendix F: Site Characterization

Each site entry contains the ambient sound level, a list of sources of sound level spikes or peaks, along with a range of values associated with each peak. After visiting the site 3-7 times (specific value in each entry), team members collated the raw site visitation lists to more manageable source pages. Whenever a single value is listed for a particular source, it implies the source was recorded once. As such, this value cannot be held to an exact standard.

SJA2_02_1036 (Parque Central)

- Number of visits: 6
- Ambient Level: 58 dB - 60 dB
- Sources:
  - Birds 66 dB
  - Cars 60 dB - 79 dB
  - Horns/Sirens 61 dB - 87 dB
  - Machinery 65 dB - 77 dB
  - Motorcycle 64 dB - 74 dB
  - Natatorium Activity 60 dB - 63 dB
  - People 61 dB - 67 dB
  - Traffic 63 dB - 77 dB
  - Truck 60 dB - 90 dB

SJA2_05_1100 (Universidad de Sagrado Corazón)

- Number of visits: 7
- Ambient Level: 49 dB - 55 dB
- Sources:
  - Bird 56 dB - 64 dB
  - Bus 72 dB
  - Cars 54 dB - 75 dB
  - Cars with Music 62 dB - 67 dB

- Horns/Sirens 55 dB - 74 dB
- Motorcycle 63 dB - 77 dB
- People 55 dB - 62 dB
- Plane 60 dB - 71 dB
- Squealing Cars 56 dB - 69 dB
- Truck 55 dB - 83 dB
- Van 60 dB - 75 dB

SJA3_03_1228 (Calle Cuba)

- Number of visits: 3
- Ambient Level: 48 dB - 51 dB
- Sources:
  - Birds 52 dB - 57 dB
  - Brakes 73 dB
  - Car (Mod) 66 dB - 71 dB
  - Car Playing Music 56 dB - 75 dB
  - Cars 53 dB - 76 dB
  - Generator 60 dB
  - Horns/Sirens 59 dB - 66 dB
  - Motorcycle 64 dB
  - People 52 dB - 60 dB
  - Plane 55 dB - 68 dB
  - Rooster 51 dB - 55 dB
  - Squeaking car 65 dB
  - SUV 59 dB - 75 dB
  - Truck 60 dB - 86 dB
  - Van 58 dB - 72 dB
  - Weed Whacking 51 dB

SJA4_06_0417 (Calle 19)

- Number of visits: 6

- Ambient Level: 40 dB - 51 dB
- Sources:
  - Birds 40 dB - 56 dB
  - Cars 50 dB - 74 dB
  - Construction 55 dB
  - Dog 56 dB
  - Horns/Sirens 52 dB
  - Motorcycle 55 dB
  - Person 50 dB - 64 dB
  - Plane 57 dB - 60 dB
  - Trees/Leaves/Wind 37 dB - 53 dB

SJA4_10_0714 (Centro Médico)

- Number of visits: 7
- Ambient Level: 60 dB - 65 dB
- Sources:
  - Ambulance 69 dB - 82 dB
  - Bus 66 dB - 93 dB
  - Cars 60 dB - 80 dB
  - Horns/Sirens 62 dB - 95 dB
  - Motorcycles 83 dB
  - People 67 dB - 75 dB
  - Plane 70 dB
  - Train 70 dB
  - Truck 63 dB - 75 dB
  - Van 66 dB - 76 dB
  - Wind 65 dB

SJA5_08_0957 (República de Colombia)

- Number of visits: 7
- Ambient Level: 45 dB - 53 dB

- Sources:
    - Bike/Scooter 63 dB - 85 dB
    - Birds 50 dB - 65 dB
    - Bus 57 dB - 78 dB
    - Car Playing Music 52 dB - 59 dB
    - Cars 50 dB - 79 dB
    - Dog 51 dB - 75 dB
    - Horns/Sirens 49 dB - 74 dB
    - Motorcycle 53 dB - 64 dB
    - People 51 dB - 57 dB
    - Plane 52 dB - 65 dB
    - Rooster 47 dB - 57 dB
    - Squealing Car 61 dB
    - SUV 50 dB - 65 dB
    - Truck 53 dB - 75 dB
    - Van 51 dB - 66 dB
    - Weed Whacking 50 dB - 60 dB
    - Wind/Leaves 51 dB - 63 dB

SJA5_09_1134 (Barbosa)

- Number of visits: 7
- Ambient Level: 60 dB - 68 dB
- Sources:
    - Traffic 60 dB - 81 dB
    - Cars 59 dB - 78 dB
    - SUV/Vans 60 dB - 78 dB
    - Trucks 61 dB - 82 dB
    - Bus 65 dB - 77 dB
    - Music nearby 61 dB - 74 dB
    - Plane 67 dB - 77 dB
    - Ambulance/Sirens 65 dB - 79 dB

- Car Horn 62 dB - 72 dB
- Bird 63 dB - 76 dB
- Motorcycles 71 dB - 75 dB
- Dog Barking 61 dB
- Lawn Maintenance 61 dB

SJA6_07_1872 (Colegio Mizpa)

- Number of visits: 4
- Ambient Level: 40 dB - 45 dB
- Sources:
    - Truck 54 dB - 73 dB
    - SUV 58 dB - 60 dB
    - Horns/Sirens 51 dB - 66 dB
    - Traffic 52 dB - 65 dB
    - Cars 51 dB - 80 dB
    - Plane 52 dB
    - People 52 dB - 68 dB
    - Wind/Leaves 48 dB - 53 dB
    - Motorcycle 55 dB - 75 dB
    - Van 54 dB - 61 dB
    - Bus 51 dB - 66 dB
    - Car Brake 57 dB
    - Bird 51 dB - 55 dB
    - Car Playing Music 54 dB - 64 dB
    - Brakes 52 dB - 71 dB
    - Dog 50 dB

Appendix G: Ipsos Survey

Please see attached files for survey.

Appendix H: Selected Noise-Related Laws

Law 71 (April 26, 1940)

La Ley 71 define en su artículo 2 los sonidos en ruidos innecesarios cuando estos resultan en ruidos intolerables que afectan la tranquilidad y el pacifico vivir, el que realiza o provoca el ruido innecesario incurre delito de naturaleza menos grave.

La ley 71 en su artículo 1

- Prohíbe los ruidos innecesarios de todas clases que provienen:
- Claxon o bocina de vehículos de motor
- Por falta de amortiguador de sonido en los vehículos de motor
- Por sistema de alarma en la zona urbana,
- Radios, componentes y amplificadores o altoparlantes que circulen por las calles con fines comerciales,
- Cualesquiera otros también innecesarios que se produzcan por medio de cualquier otro aparato, utensilio o instrumento, no importa su nombre, naturaleza o denominación Ejemplo:
- Equipos de construcción, equipos de muisca durante la campaña política.

Artículo 2: Ruido innecesario, definición de. (33 L.P.R.A. sec. 1444)

Se entenderá como ruido innecesario todo sonido fuerte, perturbante, intenso y frecuente que, a la luz de la totalidad de las circunstancias, resulte intolerable, afectando la tranquilidad y el pacífico vivir.

El artículo 3 dispone: que el tono de los aparatos de radio no debe ser tan alto que se oiga desde la calle, ni en forma tal que importune a los vecinos.

Los aparatos llamadas "velloneras" tendrán que ser reducidas en su volumen considerablemente con el fin de que su funcionamiento no cause molestias al público. Se puede aplicar en los cafetines de campo.

Intervención del agente del orden público al amparo de la ley 71

- Cuando se recibe una querella por ruidos, el agente llega al lugar y si desde la patrulla puede escuchar ruidos excesivos y perturbante, se configuran los elementos del delito. No se necesita ninguna máquina para medir el ruido.
- Se cita a la persona que incurre la conducta o que tiene el control del lugar donde se comete la conducta. Ej. Dueño de casa o negocio.

La violación a la Ley de delitos contra la paz pública constituye un delito menos grave. De ser declarado culpable se expone la persona que se le imponga no menor de cien (100) dólares ni mayor de doscientos (200) dólares. Cuando el delito se comete con un vehículo de motor alterado con el propósito de producir ruido, la multa no será menor de doscientos (200) dólares ni mayor de quinientos (500) dólores.

Law 155 (May 15, 1937)

La Ley fue titulada "Para Imponer un Contribución o Arbitrio sobre todo Amplificador o Altoparlante que se use en Puerto Rico para Difundir Anuncios o Cualquier otra Clase de Propaganda; para Legalizar su funcionamiento; para Imponer Penalidades por el uso Impropio de los Mismos, y para otros Fines."

Sección 1.- Definición: A los fines de esta Ley se considera como 'amplificador o altoparlante' todo artefacto provisto de bocina y válvulas de radio o cualquier otro invento, que se use para dar mayor volumen y alcance a la voz, la música o el sonido.

Sección 2. – Por la presente se impone una contribución de sesenta (60) dólares anuales sobre todo amplificador o altoparlante que se use en Puerto Rico para difundir cualquier clase de propaganda comercial o industrial, ya sean dichos amplificadores o altoparlantes portables o instalados sobre vehículos de cualquier clase o colocados en sitios fijos y conectados por alambre a un micrófono receptor. Esta contribución será pagada al Tesoro de Puerto Rico Mediante licencias trimestrales cancelando los correspondientes sellos de rentas internas; Disponiéndose, que toda persona natural o jurídica que opere un amplificador o altoparlante deberá llevar consigo la licencia creditiva de haber pagado el impuesto creado por esta Ley y deberá mostrarla cuando fuere requerido por algún agente de la autoridad.

Sección 3. – Queda prohibida la operación o funcionamiento de toda amplificador o altoparlante durante las horas de la noche comprendidas entre las 10:00 P.M. y las 8:00 A.M. por ser ello contrario a la tranquilidad pública, salvo cuando éstos fueron usados por las autoridades para prevenir al vecindario de la proximidad de un temporal, incendio o cualquier otro peligro que amenace la seguridad pública.

Tampoco se permitirá instalar un amplificador o altoparlante o hacerlo funcionar a una distancia de menos de treinta metros de cualquier hospital, casa de maternidad o sitio donde hubiera alguna persona enferma de gravedad.

Sección 4. - Será ilegal y contrario a las disposiciones de esta Ley y motivo para la inmediata cancelación de la licencia el uso de los amplificadores o altoparlantes, a saber:

- Para difundir falsos anuncios con el propósito de engañar al público o defraudarle en sus intereses;
- Para insultar, difamar o tratar de desacreditar a cualquier persona natural o jurídica de Puerto Rico, o para difundir información falsa o libeloso
- Para expresarse en forma deshonesta o atentatoria a la moral pública;
- Para despreciar, obstruir, ofender o ridiculizar la autoridad y dignidad de cualquier funcionario público de los Estados Unidos y de Puerto Rico o de cualquier país extranjero que esté de visita en Puerto Rico;
- Para incitar a la rebelión, al motín o a la desobediencia de la ley;
- Para entorpecer la celebración de cualquier acto público que se esté celebrando legalmente.

Sección 7. - Las personas que infrinjan ESTA Ley serán culpables de delito menos grave (misdemeanor) y convictas que fueren serán castigadas por primera vez con multa mínima de diez (10) dólares y máxima de veinticinco (25) dólares o un día de cárcel por cada dólar que dejen de pagar, o ambas penas; y si fueren reincidentes con pena mínima de cincuenta (50) dólares y máxima de cien (100) dólares o un día de cárcel por cada dólar que deje de pagar, o ambas penas a discreción del tribunal.

Sección 8. – Nada de lo contenido en esta Ley se interpretará en el sentido de limitar el tiempo para la celebración de cualquier acto de carácter político, religioso, obrero o social, que pueda celebrarse en las plazas o sitios públicos autorizados por ley.

Sección 9.- Toda ley o parte de ley que se oponga a la presente, queda por ésta derogada.

Sección 10. –Esta Ley empezara a regir a los noventa días después de su aprobación.

Aprobada en 15 de mayo de 1937.

Law 416 (May 9, 2011)

DERECHO DE UN FUNCIONARIO A ACCEDER, INSPECCIONAR, EXAMINAR O LLEVAR A CABO CUALQUIER ACCIÓN PERTINENTE

A) La JCA. representada por sus miembros, agentes o empleados, podrá acceder, inspeccionar, examinar y llevar a cabo cualquier otra acción autorizada por este Reglamento, por la Ley sobre Política Pública Ambiental, supra, por la Ley de Procedimiento Administrativo Uniforme, supra, o por un Tribunal con jurisdicción y competencia. Estas acciones podrán llevarse a cabo en cualquier local, equipo, instalación y/o documentos de cualquier persona, entidad, firma, agencia o instrumentalidad gubernamental sujeta a su jurisdicción. Estas gestiones serán realizadas con el fin de investigar, inspeccionar o tomar aquellas medidas que se estimen necesarias para asegurar las mejores condiciones ambientales, verificar el cumplimiento con las disposiciones de este Reglamento y tomar las medidas de sonido que la JCA estime necesarias.

B) En caso de que a un funcionario de la JCA que esté identificado como tal, se le niegue el acceso o se le impida realizar una inspección o cualquier acción autorizada en ley, la JCA podrá expedir una orden administrativa u obtener una orden judicial, según los procedimientos dispuestos por la Ley sobre Política Pública Ambiental, supra, la Ley de Procedimiento Administrativo Uniforme, supra, o cualquier otra ley especial.

C) Cualquier solicitud de documentos que se encuentre dentro del ámbito jurisdiccional de la JCA que sea hecha por un funcionario de esta agencia y que esté debidamente identificado y autorizado para llevar a cabo una inspección o cualquier asunto comprendido en la Ley de Política Pública Ambiental, supra, o en este Reglamento, tendrá que ser provista dentro de un término no mayor de cuarenta y ocho (48) horas o aquel período de tiempo que disponga la JCA.

INFORMACIÓN DISPONIBLE AL PÚBLICO

A) Toda información recibida por la JCA estará disponible para ser inspeccionada y copiada por el público, según dispuesto en la Ley sobre Política Pública Ambiental, supra, en este Reglamento o en cualquier mecanismo que para ello se apruebe por la JCA.

B) Cualquier persona que someta información y documentos a la JCA. Podrá reclamar confidencialidad para toda o parte de la información o documento sometido. Dicha solicitud deberá realizarse por escrito y expondrá todas las razones por las cuales se solicita la confidencialidad.

C) Cualquier información o documento presentado a la JCA sin haberse presentado la correspondiente solicitud de confidencialidad conforme a lo aquí dispuesto, estará disponible al público sin restricción alguna. La JCA adjudicará los reclamos de confidencialidad de conformidad con la Ley sobre Política Pública Ambiental, supra, o cualquier mecanismo que a tales efectos apruebe la Junta de Gobierno de la JCA.

NOTIFICACIÓN DE VIOLACIÓN Y ÓRDENES ADMINISTRATIVAS

A) Siempre que [a JCA encuentre que una o más disposiciones de este Reglamento han sido violadas o haya motivos fundados para pensar que han sido violadas, la JCA podrá, a su discreción, expedir por escrito una notificación de violación en contra del alegado infractor. Toda notificación especificará en qué consistió la violación y/o los aspectos que están fuera de cumplimiento con esta reglamentación.

B) La notificación de la que habla el inciso anterior especificará los requisitos y las condiciones que la JCA determine necesarios y podrá incluir términos de tiempo para lograr cumplimiento. No obstante lo antes mencionado e independientemente de que se haya expedido una notificación de violación, [a JCA podrá expedir una Orden Administrativa de Hacer, Mostrar Causa y/o, Cese y Desista, así como cualquier otra acción o provisión disponible en la Ley sobre Política Pública Ambiental, supra.

RUIDOS PROHIBIDOS

Las siguientes acciones, entre otras, se declaran como ruidos contaminantes, excesivos, perturbadores y estridentes y están prohibidos por este Reglamento:

Bocinas y sirenas

Ninguna persona ocasionará o permitirá, innecesariamente, el sonar de bocinas y sirenas de cualquier vehículo de motor en una vía pública o predio originador de sonido, excepto como una señal de peligro o en casos de emergencia, según definido en este Reglamento.

Radios, instrumentos musicales, velloneras, amplificadores y artefactos similares

Ninguna persona operará o permitirá la operación de cualquier radio, instrumento musical, vellonera, amplificador o cualquier artefacto similar para la producción o reproducción de sonido, de tal forma que ocasione contaminación por ruido a través del límite de propiedad, en violación de los límites fijados en este Reglamento.

Altoparlantes exteriores, megáfonos y artefactos similares

Ninguna persona usará u operará o permitirá el uso u operación de cualquier altoparlante, megáfono o artefacto similar en una posición fija o movible en el exterior de cualquier estructura o vehículo de motor, en exceso de los niveles máximos permitidos bajo este Reglamento. No podrán usarse dichos artefactos durante el periodo nocturno.

Construcción

Ninguna persona usará u operará o permitirá el uso u operación de cualquier equipo para la construcción, reparación o trabajos de demolición, de forma que se produzca contaminación por ruido, según se define en este Reglamento. Además, se prohíbe el uso u operación de dicho equipo durante el periodo nocturno, excepto para realizar obras en casos de emergencia, según definido en este Reglamento. Esta Sección no aplicará al uso de herramientas domésticas, sujeto a este Reglamento.

Vehículos de motor

a) Ninguna persona operará o permitirá la operación de un vehículo de motor en una vía pública en cualquier momento de forma tal que los niveles de presión de sonido emitidos por el vehículo excedan los niveles máximos permisibles establecidos en este Reglamento. Tampoco se permitirá la operación de un vehículo de motor que no esté equipado por un sistema, aparato o artefacto amortiguador de sonido que opere eficientemente.

b) Ninguna persona dejará operando o permitirá la operación de cualquier vehículo de motor o cualquier equipo auxiliar de arrastre estacionado en una vía pública o predio de estacionamiento público o privado, a una distancia menor de 150 pies de la zona designada como residencial o tranquilidad durante el periodo nocturno. Esta prohibición abarca todo equipo que for-me parte del vehículo de motor, tales como, pero no limitados a, equipo de refrigeración o equipo similar.

Eventos de vehículos de motor de carreras

Ninguna persona realizará o permitirá la realización de pruebas o carreras de vehículos de motor, en violación de las normas establecidas en este Reglamento. Dicha prohibición está exceptuada para aquellas pistas autorizadas en forma prescrita por la JeA.

Vehículos de recolección de desperdicios sólidos

a) Ninguna persona operará o permitirá la operación del mecanismo de compactar desperdicios sólidos en cualquier vehículo de motor, de tal forma que durante el ciclo de compactación se exceda el nivel de presión de sonido de 76 dB(A) medido a una distancia de 23 pies o su equivalente, desde cualquier punto del vehículo.

b) Ninguna persona recolectará o permitirá la recolección de desperdicios sólidos en las zonas residenciales y de tranquilidad entre las 10:00 p.m. de un día a las 6:00 a.m. del siguiente día.

Alarmas

Ninguna persona sonará o permitirá el sonar de cualquier alarma exterior en cualquier edificio o vehículo a menos que tal alarma cese su operación dentro de diez (10) minutos luego de ser activada y cuya finalidad tenga el propósito de alertar una emergencia u acto criminal.

Maquinaria, equipo, abanicos y acondicionador de aire

Ninguna persona operará o permitirá la operación de maquinaria, equipo, abanicos y acondicionadores de aire de tal forma que excedan los límites máximos de niveles de presión de sonido establecidos en este Reglamento.

Reparación y prueba de vehículos de motor

La reparación, remodelación, reconstrucción, fabricación o prueba de cualquier vehículo de motor o motocicletas estará sujeta a los niveles máximos permisibles de sonidos fijados en este Reglamento.

Equipo de motor doméstico (Domestic Power Tools)

Ninguna persona operará o permitirá la operación de equipos de motor tales como: sierras, lijadoras, taladros, máquinas de cortar grama y equipo de jardín o herramientas de cualquier naturaleza, usados primordialmente para propósitos domésticos en el exterior e interior de residencias, durante las horas que comprende el periodo nocturno. Tampoco se podrá operar o permitir la operación de tal equipo de motor en cualquier momento, de tal forma que viole las disposiciones de este Reglamento.

Venta por pregono

Ninguna persona venderá o permitirá la venta de cualquier producto pregonando en cualquier área, mediante el uso de sistemas de amplificación, de forma que la emisión de sonidos exceda los niveles máximos permisibles especificados en este Reglamento. Además, queda prohibida la venta por pregono durante el periodo nocturno.

Vibración

Ninguna persona operará o permitirá la operación de cualquier artefacto que genere vibraciones causadas por ondas sonoras o presión de sonido que puedan percibirse sin instrumentos, o que esté sobre los límites de percepción de una persona, en o más allá de los límites de cualquier propiedad contigua a la fuente originadora.

APLICABILIDAD

Esta Parte aplica a la fuente emisora o predio originador de cualquier sonido que pueda cruzar los límites de propiedad y exceder los niveles establecidos en la Tabla, según medido en la zona receptora apropiada.

CLASIFICACIÓN DE ZONAS

A. Zona I: Residencial - Incluye, pero no se limita, a áreas tales como las siguientes:

1. Residencias

   permanentes

   rurales o campestres

   de verano

2. Viviendas comerciales

   hoteles y moteles

   apartamentos alquilados

   parques de casas móviles

   campamentos

   cabañas

   casa de huéspedes

   dormitorios estudiantiles

3. Servicios a la comunidad

   orfanatos

   instituciones correccionales

   instituciones de caridad

B. Zona II: Comercial-Incluye, pero no se limita, a áreas tales como:

1. Establecimientos comerciales de alimentos

   restaurantes

   comedores

   cafeterías

   heladerías

   clubes nocturnos

   cafetería al aire libre o rodante

   carnicerías

   supermercados

2. Estaciones de servicios de vehículos

   gasolineras

   venta y renta de vehículos de motor

estacionamientos de vehículos públicos y privados

centro de lavado de vehículos de motor

servicios de reparación (hojalatería, pintura y mecánica, electrónica)

servicio de accesorios para vehículos de motor

3. Comerciales

   funeraria

   clínicas veterinarias

   barberías

   salones de Belleza

   lavanderías

   oficinas

   farmacias

   centros comerciales

4. Recreación y entretenimiento

   teatros

   estadios

   hipódromos

   campos de golf

   lugares de diversiones y recreación

   playas, Ríos, Lagos y Lagunas

   plazas públicas

   gimnasios

   salones de bailes y discotecas

5. Servicios comunales

   iglesias

   centros culturales

   cotos de caza y pesca

   bosques estatales o nacionales

C. Zona III: Industrial - Incluye, pero no se limita, a áreas tales como:

1. Establecimientos de carga y descarga

   ferreterías

almacenes, madereras, tiendas de ventas al por mayor
terminal de camiones
muelles
depósito de materiales de construcción
instalación de desperdicios sólidos no peligrosos o peligrosos

2. Área industrial: propiedades utilizadas en la fabricación de bienes de consumo
   minería
   industrias livianas y pesadas
   petroquímica
   refinerías
   extracción y procesamiento de materiales de la corteza terrestre
   siderúrgicas
   canteras
   central termoeléctrica
   farmacéuticas
   procesamiento agroquímicos
   almacenamiento de tanques de gas
3. Agricultura: área utilizada en la producción de cultivos de cosechas y/o crianza de animales
   granjas avícolas, conejos, porcinos y apicultura (abejas)
   vaquerías
   invernaderos
   graneros
   siembra, cultivo
   caballerizas

D. Zona IV: Tranquilidad -Incluye, pero no se limita, a áreas tales como:

1. Hospitales
2. Clínicas
3. Hospitales de salud mental
4. Tribunales de justicia
5. Asilos de ancianos

6. Escuelas
7. Guardería o cuidos infantiles

LÍMITES DE NIVELES DE SONIDO PARA AEROGENERADORES O SISTEMAS DE GENERACIÓN DE ENERGÍA EÓLICA

A fin de establecer los límites de sonido para los casos en que la fuente emisora de sonido es un aerogenerador o sistema de generación de energía eólica, según definido en este Reglamento, se aplicará la Tabla I con los siguientes ajustes:

A. Cuando la fuente emisora es un aerogenerador o sistema de generación de energía eólica y la zona receptora es una Zona I (residencial), para el periodo nocturno con un nivel de sonido establecido de 50 dB(A), se realizará el ajuste de añadir 5 dB(A), a fin de que el nivel de sonido en estos casos sea de 55 dB(A).

B. Cuando la fuente emisora es un aerogenerador o sistema de generación de energía eólica y la zona receptora es una Zona IV (tranquilidad) para el periodo nocturno con un nivel de sonido establecido de 50 dB(A), se realizará el ajuste de añadir 5 dB(A), a fin de que el nivel de sonido en estos casos sea de 55 dB(A).

TABLA I
LIMITE DE NIVELES DE SONIDO
dB(A)
Nivel de Sonido Excedido en 10 % del Periodo de Medición (L10)

FUENTE EMISORA	ZONAS RECEPTORAS							
	Zona I (Residencial)		Zona II (Comercial)		Zona III (Industrial)		Zona IV (Tranquilidad)	
	D	N	D	N	D	N	D	N
Zona I (Residencial	60	50	65	55	70	60	55	50
Zona II (Comercial)	65	50	70	60	75	65	55	50
Zona III (Industrial)	65	50	70	65	75	75	55	50
Zona IV (Tranquilidad	65	50	70	65	75	75	55	50

EXCEPCIONES A LAS PROHIBICIONES

Durante el periodo diurno

Las prohibiciones establecidas en esta Regla aplicarán a las fuentes emisoras o predio originador de cualquier sonido que pueda cruzar los límites de la propiedad. Las siguientes acciones, cuando se lleven a cabo durante el periodo diurno (7:00 a.m. a 10:00 p.m.), estarán exentas de los requisitos establecidos en este Reglamento:

- los sonidos emitidos por los proyectos temporeros para la reparación y mantenimiento de hogares y sus dependencias,
- los sonidos emitidos durante la instalación y reparación de servicios públicos esenciales,
- los sonidos emitidos por un disparo de armas livianas de fuego en polígonos de tiro autorizados.

Emergencias

No se considerará contaminación por ruido aquel sonido que, generado en exceso de los niveles autorizados en este Reglamento, sea realizado al efectuarse un trabajo de emergencia, según definido en este Reglamento, para proteger la salud, seguridad o bienestar inmediato de la comunidad o individuos, o restauración de la propiedad como medida de seguridad luego de un desastre. Nada de lo contenido en este inciso se entenderá como que permite al personal de emergencia, policías, bomberos o conductores de ambulancias y otros similares a producir ruidos durante el cumplimiento de sus deberes cuando tales ruidos sean claramente innecesarios.

Excepciones generales

Las siguientes situaciones se considerarán como excepciones adicionales a la prohibición de ruidos, según definido en este Reglamento:

- los sonidos emitidos por artefactos para la prevención de accidentes;
- los sonidos emitidos por asambleas, actos públicos y paradas no rutinarias;
- los sonidos emitidos por el disparo de armas livianas de fuego durante la temporada de caza siempre que se produzcan en áreas designadas para esos fines;

los sonidos emitidos por las calderas de refinerías de petróleo y las plantas generatrices de electricidad durante el encendido de esas calderas;

los sonidos emitidos por campanas, campanarios y/o carillones que se extienden hasta quince (15) minutos;

el sonido emitido por la voz humana no amplificada;

el sonido emitido por los animales;

el sonido emitido por el encendido de plantas de emergencia como parte del proceso de calentamiento, siempre que no exceda los diez (10) minutos; y

el sonido emitido por los aeroplanos, ya que el mismo está regulado por la Ley Federal de la Administración Federal de Aviación (Federal Aviación Administración) y las normas de ruido establecidas por la Agencia Federal de Protección Ambiental (Environmental Protection Agency) para la manufactura de nuevos productos.

Glossary of Terms

Área de Control de Ruidos (ACR)

Translated, Noise Control Area. A subdivision of the JCA that focuses on noise pollution (Alicea-Pou, 2013).

Coefficient of Variation (*CV*)

An indication of the amount of variability of a given dataset. It is calculated as $CV = STD/AVG * 100$, wherein STD is the standard deviation and AVG is the average of the dataset. In relation to this project, the greater the *CV* value for a particular time, the greater the temporal variability at that time within the days of gathered decibel levels (Abdi, 2010).

Comité Interagencial y Ciudadano ante el Ruido (CICAR)

Translated, Citizen's Interagency Committee on Noise. A coalition made up of representatives from the JCA, the Police of Puerto Rico, the Departments of Health and Education, the Planning Board, the University of Puerto Rico, and several other organizations. CICAR seeks to create an *Action Plan Against Noise in Puerto Rico*, which would combine the resources of these agencies to effectively reduce noise pollution in the commonwealth (Ambiental, 2005, 2009, 2010).

Decibel (dB)

A (base 10) logarithmic measure of the ratio of the intensity of a sound at a specific frequency to the intensity of a reference sound (the faintest sound that can be heard) at the same frequency ("Sound Intensity (Physics)", n.d.).

Impulsive Sound

Sudden spikes of sound, such as a car horn (Møller et al., 2012).

Intensity

The average energy flow through a given area of the medium transmitting the wave per unit time. Alternatively, the power of the wave per unit time. Measured in phon ("Sound", n.d.).

Junta de Calidad Ambiental (JCA)

Translated, Environmental Quality Board. State-level environmental protection agency of Puerto Rico (Alicea-Pou, 2013).

L_{10}

The 90th percentile of a dataset of decibel levels. Alternatively, the decibel level exceeded 10% of the time (Alicea-Pou, 2013).

L_{90}

The 10th percentile of a dataset of decibel levels. Alternatively, the decibel level exceeded 90% of the time (Alicea-Pou, 2013).

L_{eq}

The 50th percentile, or median, of a dataset of decibel levels. Alternatively, the decibel level exceeded 50% of the time (Alicea-Pou, 2013).

Noise

Any unwanted, undesired, or over-stimulating sound. Alternatively, any sound that interferes with everyday activities such as sleeping, working, or having a conversation (Hansen, 1994; Kerwin, 2012).

Noise Pollution

Any noise which endangers the health and safety of humans ("Regulation for the Control of Noise Pollution", 2011).

Sound (Audible)

Fluctuations in atmospheric pressure with frequencies within 20 Hz-20,000 Hz, the range of human hearing, transmitted through a medium ("Sound", n.d.; Hansen, 1994).

Sound (Non-audible)

Fluctuations in atmospheric pressure with frequencies outside the range of human hearing – that is, lower than 20 Hz and higher than 20,000 Hz – transmitted through a medium ("Sound", n.d.; Hansen, 1994).

Sound Pressure Level

A (base 10) logarithmic measure of the ratio of the sound pressure of a given sound to a standard reference point. See decibel (“Regulations for the Control of Noise Pollution”, 1987).

Soundscape

A concept popularized by Murray Schafer in the 1960s and 1970s, a compilation of all types of sounds (pleasant and unpleasant) in a given area or region with the public perceptions of these sounds (Szeremeta and Zannin, 2009).

Tonal Noise

Very noticeable noise with a lot of energy at a single frequency or in a very narrow frequency band (“A Brief Guide to Noise Control Terms”, 2013).

Volume

Loudness of sound. Alternatively, the attribute of sound determining the intensity of sensation, a highly subjective unit, and not suggested for academic research (“Loudness”, n.d.).